Cloud Architectures

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***Abstract*—This paper presents a case study for Scottish Power Limited by comparing the traditional architecture of On-premise High-performance computing(HPC) with Cloud-based architecture. This paper will be suggesting an economical cloud migration plan of the current HPC-based application of Scottish power depicts what all AWS services will be using to get a cost-effective and efficient roadmap. Also, identify for what all applications Scottish power is using its current HPC computing and calculating the server and storage cost. After that Calculating what all services will be the best suitable to replace the current on-prem server and Storage.**

I. Introduction

The the objective of this paper is to analyze the economic benefits of Scottish Power Limited by adopting a cloud-based HPC architecture using AWS services. Below will be the main focus area of this paper :
1- Identifying the applications which are using current HPC computing.
2 - Calculating cost of current on-premises setup of Scottish Power.
3- Architect the cloud Infrastructure needed and enlisting all AWS services used for migrating the current infrastructure to the cloud.
4- Cost estimation of proposed cloud infrastructure setup.
5- Comparison of current on-premises setup with Cloud-based HPC Architecture.

II. Company Description

ScottishPower Limited was established in 1990 and based in Glasgow. It comes under the list of UK's one the first integrated energy firm which uses renewable resources(wind energy) for electricity generation.Scottish Power is part of the Iberdrola Group. The company have Total Revenue of 5124.5 million Pound and have an operating cost of 822.5 million Pound. A total number of employee working are 5,500.

The company's key goal is to provide cleaner electric transportation also improving air quality over time. By delivering a low-carbon future for the UK, they create a better and eco-friendly future faster. The company is producing 100Percent green electricity by using wind energy and smart grid systems.

III. Analysis of the Company's Current on-premises HPC state

Scottish Power has its headquartered on the south side of Glasgow.

TABLE I
CPU Specifications

113.556	Intel Xeon Processor E5-2628L v2
Cores	8
Threads	16
Cache	25 MB Intel Smart Cache
Memory Type	DDR3 800/1066/1333/1600
Processor Base Frequency	3.00 GHz
Maximum Memory Size	768 GB
Max Memory Bandwidth	51.2 GB/s
Instruction Set	64-bit

Considering Scottish Power is using HPC computing mainly on two major applications, which will be Security and Reliability Assessments and running their company's web application and mobile application.

1- Security and Reliability Assessments :
The Evaluation of Security and reliability in power systems is an important component to prevent overload, voltage instability, and blackouts. It is of most important for industries to analyze the status of the power networks. Since many simulations, many contingency scenarios, real-time security, and reliability evaluations are computationally intensive, so we cannot use our traditional computing platform. There was a paper presented [1] a computation architecture for complex security assessments that incorporates the use of phasor data with an advanced computing platform. In order to evaluate the power network dynamic protection in a predictive manner, the system parallelized dynamic state estimation algorithms and contingency analysis cases across a cluster of 64 cores. Reference paper on product high-performance computing frameworks [2] tends to control framework probabilistic and security investigation.

2- Hosting Web and Mobile application through HPC Computation:
Scottish Power has a total of 5 million customers. Most of the interaction between Scottish Power and their customers takes place from the company's Web Application and their Mobile application. But a great number of customers of Scottish power have faced technical failure with the company's current application. Below are the few Customers complaints that have been registered by customer:
1- Application constantly giving error.

2- Unable to access the account.
4- Bad customer support service.
3- Billing Dashboard is not visible. By migrating to cloud-based architecture we might be able to rectify both mobile and web application's technical issues more economically.

Calculating On-Premise HPC Cost

The Above two applications is using HPC computation. Scottish Power is using an **Intel Xeon Processor E5-2628 processor**. According to the EPSRC research paper on [1] Developing Scalable Smart Grid Infrastructure to Enable Secure Transmission System Control, we found out, this application will run on **64** Cores processor. DELL PowerEdge T40 server 3.5 GHz is compatible with this Intel Xeon processor and its specification is represented in Table I. server.

The current on-premise HPC Architecture consists of:
Compute specification: 2 Servers running on Linux operating system, having 4 processors and 8 cores per processor. Consist Of RAM of **448 GB**.
Storage Specification: 10TB of storage with 5TB Backup Storage is been used to save different types of data like Customers Data, Customer's Contract data, and saving data of many simulations.

The total cost of On premise architecture can be calculated by using the [3]**Microsoft Azures Total Cost of Ownership (TCO)**. Calculator.
Figure 1 shows the proposed cloud architecture.
Total 5-year cost of on-premise HPC will be : 1,096,169 USD

Caluating Failure Rate:
Assuimng (For **5 year time duration**):
Total working time (AT) = 22*365*5
= 40150
Total Breakdown Time (DT) = 2*365*5
=3650 (Assuming server downtime 2 hr in a day
No of breakdown = 1*365*5
=5475
Mean time between failures (MTBF)
= (Total working time) - (total breakdown time / (number of breakdown)
MTBF = (AT - DT)/ n

MTBF= 6.66
Failure Rate = 1/6.66 = 0.150

IV. Proposed Cloud-based HPC Architecture

Proposing a cloud-based architecture using Amazon Web Services(AWS), we will be architecting the above applications and analyze if migrating to the cloud will be economical or not. Architecture mainly includes, Compute service(EC2), Storage (Dynamo-DB database), Disaster recovery (Load balancer directing Load to different Ec2 servers which are placed in different availability Zone).

This Architecture will be using **Route53**, which is a highly dependable and cost-effective method for routing end user's request (Customers) to Internet applications. Then we have included **CloudFront** which is AWS's network backbone and provides the customer a fast, stable, and reliable experience. CloudFront reduces the burden on your **S3 bucket** by caching your content in Edge Locations, resulting in a quicker response for your users when they request content. Furthermore, using CloudFront to serve content is always less expensive than serving files directly from S3, and there is no data transfer charge from S3 to CloudFront. You just pay for what is delivered to the internet from CloudFront, plus request fees. The user Request passes through the internet Gateway and mainly helps to add an internet routable traffic target to your VPC route tables.
We have added an **Elastic Load Balancer** to route the request to Ec2 servers. We have added **Ec2 servers in two different Availability Zone A and B**. This will help in case of disaster recovery. Considering in case if one whole availability zone is unavailable then the load balancer will automatically divert the traffic to other Ec2 servers which are placed in another Availability Zone. There is an Auto Scaling group that is used to scale up or down Ec2 instances depending on the needs of the consumer and the situation like Peak load situation.
(NAT) gateway is also included that will allow Ec2 instances which are present in a private subnet to connect to the internet while preventing the internet from connecting to such instances.
An **RDS (Relational Database Service)** is also added which makes it easier to set up, run, and scale a database. Using RDS is very cost-effective because of its resizeable capability for relational databases. We have also included the **RDS-Multi AZ** option which will generate a primary DB Instance and synchronously replicates the data to a standby instance in a separate Availability Zone Each AZ is designed to be highly durable.
Cloud Watch is been used to get the real-time metrics and monitor logs of EC2 servers, RDS.
SNS(Simple Notification Service) helps to get notifications of events on registered mail or on mobile.
Figure 2 shows the proposed cloud architecture.

A. Multi-Variable Cost

The cost of AWS services can be calculated [4] from the **SIMPLE MONTHLY CALCULATOR of AWS**. Calculating the proposed Cloud-based architecture cost will mainly include the computing cost of Ec2 server, EBS(Elastic Block Storage), Database cost.

RDS Core used in this architecture is **db.r4.2xlarge** which is good for Memory-intensive programs, also they have their own instance classes. They provide better networking as well as Amazon EBS efficiency.
EC2 core type: Linux on **g3.4xlarge (Having 16vCPU and Memory of 122 each)**. The main application of this core is that it used for parallel processing and also networking

Cost over 5 year(s)

On-premises cost breakdown summary

Category	Cost
Compute	$123,843.20
Hardware	$109,820.00
Software	$0.00
Electricity	$14,023.20
Data Center	$42,317.80
Networking	$918,943.95
Storage	$6,464.00
IT Labor	$4,600.00
Total	**$1,096,169.00**

Fig. 1. On-premise Cost

throughput for machine learning and HPC applications.

Compute Cost :
Instance type: Linux on g3.4xlarge (On-Demand)

Total number of EC2 Server used : 5
Total number of EBS used : 5
Total Cost of EBS server = 58.00 USD per month
Total Cost of EC2 server = 5230.15 USD per month
Total Compute cost(EC2 + EBS) = 5288.15 USD per month
Storage Cost: (RDS Multi-AZ with provisioned iops SSD of Storage 10000TB and have Provisioned IOPS: 10000)

Total cost of RDS Service : 6859.68 USD per month
Cost of AWS Support (Business) = 1150.11 USD per month

Total Cost (EC2+EBS+RDS+ AWS bussiness cost) = 13294.46 USD per month

Total Cost (5-Year) = 797640 USD

V. Conclusions and Future Work

"We'd maxed out the power, which I know sounds funny given the business we're in, but we couldn't really expand quickly without investing a couple of million pounds in the site," said Damon Kirk (Data Centre Program Manager).On-premise HPC also have other costs which needs to considered like data centre related cost includes a lot factor-like **cooling, UPS charging, battery, lightning**. The cost of maintaining the data center is too much.
On comparing both cost of On-premise and Cloud based architecture, we can **estimate total cost savings could be of 308,742 USD over 5-year period**.
Figure 3 shows the comparison graph of On-premise Cost and AWS Cost for 5 years.
Benefits of Cloud Migration
1- **Cost-effective**
2- **Better storage**
3 -**Disaster recovery**
4- **Security**
5- **Less maintenance**

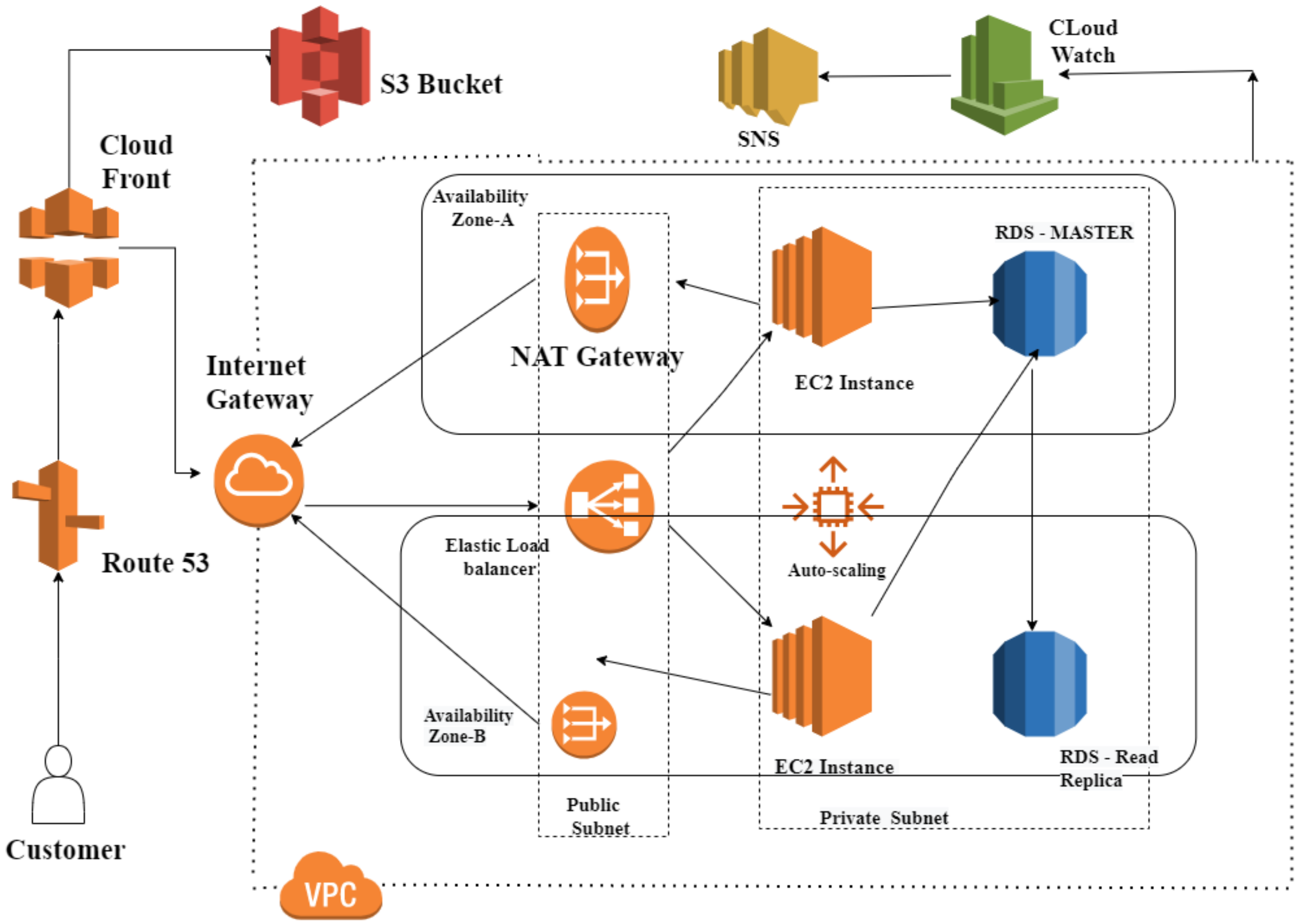

Fig. 2. On-premise vs AWS Cost Time Graph

If more public data would have available from Scottish Power regarding its Datacenter and or its total Power Consumption by the generator for cooling, Lightning, UPS and Battery Inefficiency would have been available we could have calculated approx cost spend on data center.

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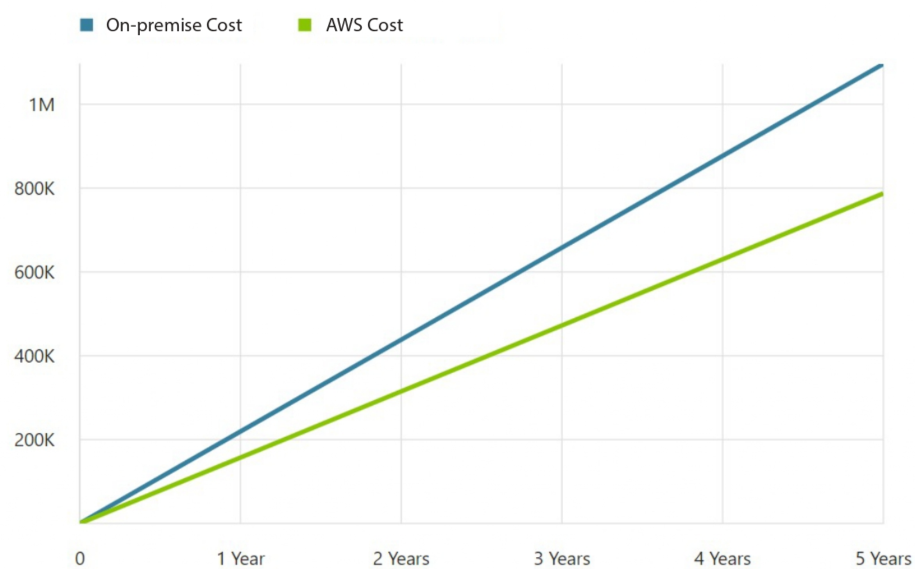

Fig. 3. On-premise vs AWS Cost Graph