**A report submitted in partial fulfilment**

**of the regulations governing the award of**

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**Reflective Report**

**KF6013 Cloud Computing**

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**A description of the chosen cloud solution including the type of solution provided and the name of the cloud provider used:**

The cloud solution I have chosen for implementing the mashup web app is Microsoft Azure, a cloud computing service provided by Microsoft.   
  
The cloud service provided by Microsoft provides tree types of cloud service models:

* IaaS: the service provider maintains and update the backend infrastructure such as compute, storage, network, and virtualization whilst the developer manages everything to do with operating systems, middleware, applications, and data.
* PaaS: the service provider manages the backend infrastructure and provides all the software tools and features needed for application development. Here, the developer only writes code and mange apps and data without worrying about managing and maintaining the software development platform.
* SaaS: the service provider delivers a complete application and all the infrastructure needed to support a client solution, being responsible for everything.

Based on this, I decided to use Azure VM as it provides Infrastructure as a Service (IaaS) and allows me to deploy and manage the web solution without worrying about the underlaying hardware.   
  
Using an Azure VM, I considered employing the following Web Service Components to satisfy the solution to client’s problem: Linux OS, Apache Web Server, PHP, HTML, JS, and CSS.  
  
Microsoft Azure is a great option for the Living Plante HQ project because of its security, scalability, and extensive range of cloud services.  
  
  
**2. Pricing information for the package used. If this is a free package, i.e. it is trial package or you are using student credits or similar, then describe the terms and conditions of any free use and what the pricing will be once the free term is ended:**

The web solution for Living Planet has been deployed on my Azure student account. This account was provided by Northumbria University and offers an initial credit of $100. In addition, it provides limited access to free products for a 12-month duration, ensuring that most of my development and implementation costs are covered during this period.  
  
For the implementation of cloud solution, I set up a Virtual Machine on Microsoft Azure. The VM is set in the East US region and utilizes a Linux operating system with an Ubuntu image. The size of VM is “Standard\_B1s” which provides 1 vCPU and 0.5 GiB memory. It's a cost-effective choice that suits the requirements of our project well. The cost of running this VM is $3.80/month or $45.60/year.

The given $100 credit enabled the development of the solution to account for any unexpected or additional costs that may arise during the project's lifespan. However, once the initial 12 months are over, or if the $100 credit is being used, the client will need to switch to a pay-as-you-go plan. This will allow them to continue running the VM at the same monthly rate of $3.80.  
  
**3. Describe how the chosen solution addresses the following ethical concerns:**   
  
**a. Client sustainability targets.**   
  
Microsoft Azure Cloud is the option that has been carefully considered and integrated as part of the solution required by Living Planet.   
  
Microsoft has been carbon neutral since 2012 and has the target of becoming carbon-negative by 2030 which aligns with client’s sustainability goal. Moreover, they are further aiming to remove all historical carbon emissions that was produces since it was founded in 1975.

Microsoft's sustainability strategy is broad and comprehensive. It includes investing funds generated from an internal carbon tax back into efforts to improve energy efficiency. However, the company is increasingly focusing on the development of innovative, carbon-smart solutions. These solutions employ data science, artificial intelligence, and digital technology to assist customers in reducing their carbon emissions.

Additionally, Microsoft plans to participate actively in public policy matters. This involves expanding applied research activities related to carbon and removing barriers for scaling technology solutions.  
  
Lastly, the VM set up in this project is relatively small sized and has a small footprint compared to larger more-resource-intense VMs which makes it a good choice for being more sustainable.  
  
**b. Security and privacy concerns – this could include information about user accounts for accessing the cloud solution, sign in requirements for accessing any of the API features, information about firewalls and any other security or privacy measures taken:**  
  
Microsoft Azure cloud platform is well known for its high level of security. The access to the Azure VM is facilitated through Azure Active Directory (AD) which provides identity services that applications use for authentication an authorization to access the Azure resources.  
  
One key feature of AAD that could be enabled for extra security is Multi-Factory Authentication (MFA) which can add extra layers of security to the log in process. It requires users to check their identity by using at least two different authentication methods before accessing the VM. This could be something like fingerprint and a phone. Therefore, if an attacker would try to compromise the VM password, he will still need the other forms of identification.  
  
For VMs, Azure also offers an integrated firewall. For instance, Network Security Groups are utilised to allow or deny network communication to the VM (SSH-22, HTTP-80, HTTPS-443), offering an additional layer of security.  
  
Each VM is connected to a Virtual Network and has a private IP address, which makes them isolated from the public internet and reducing exposure to threats.  
  
Another important feature is Azure Disk Encryption. Although it was not configured for this Virtual Machine, it can provide a volume of encryption for the data stored in the Azure VM. This could help in protecting data at rest.  
  
Lastly, access to the APIs (Twitter, Google Maps, and GeoNames) used in the web solution is secured using API keys and Google OAuth2, depending on the API provider requirements. These keys or tokens are stored securely and are not exposed to the end user.

**c. Legal requirements – for example is the solution hosted in a particular region, if so, why was this decision made, what are the cost implications and how does it allow the client to maintain GDPR requirements?**  
  
The VM was configured to be hosted in East US due to being cost-effective since the price varies from region to region. With the same configuration, the price for a VM hosted in UK West would be $4.29 whereas in East US is $3.80.  
  
Regarding the legal requirements, even if the VM is not hosted in UK, closed to Living Planet HQ, Microsoft is committed to being GDRP compliant and offers several features that help the organisation to fulfil their own compliance obligations. For instance, Azure provides many security tools that can protect data, reporting features and ability to control where the data resides.  
  
Moreover, the APIs used for this project, are protected through security means such as tokens and Google OAuth that prevent unwanted access, making the solution more adherent to GDRP requirements.  
  
  
**4. Provide a short handover plan for your solution. What information do you think your client will need to take over managing the cloud solution? You should consider whether they will be paying your organisation to manage the service or will they need to transfer any billing details over to their own organisation? What skills/information will someone need to access, manage, edit, stop, start etc the cloud solution provided 300 words:**   
  
Firstly, if the client decides to take over the cloud, they should have a basic understanding of Azure Cloud, such as starting, stopping, and monitoring a Virtual Machine. If they don’t, a comprehensive documentation must be provided for this matter.

In terms of skills, basic knowledge of cloud services, especially Azure would be beneficial. Familiarity with Linux command lines in PowerShell or CMD would be useful since the VM is running on Linux OS. This would be very important for managing and re-configuring the VM. Also, a basic understanding of APIs would be required to manage the integration of included APIs. Living Planet staff should also have some knowledge using HTML, CSS and JS with jQuery if they want to maintain the code and add extra features overtime.   
  
However, if they do not possess these skills, training should be provided through various tutorials and online sessions.  
  
As a better alternative, the client could pay my organisation to manage the cloud solution and not worry about lack of skills and knowledge.  
  
Also, if they decide to take care of the cloud payments, billing information will be given them. I would walk them through this process, making sure they are aware of the expenses involved and how to control and monitor them. To provide payment monitoring, I could allocate them as admins in the “Cost Management + Billing” service by accessing IAM service. By having assigned roles, they could take care of the billing aspect of the cloud expenses.  
  
  
**5. Describe an alternative cloud solution that you could have used and present a justification for why the chosen solution fits the requirements better. It might help to have a comparative table between your solution and the chosen one which lists the different features e.g. cost, security, usability etc. 300 words:**

An alternative to Microsoft Azure Cloud would have been Amazon Web Services (AWS). AWS is the leading cloud provider offering mostly similar services as Microsoft Azure.  
  
However for this project, I have chosen Azure for four big reasons:

* Sustainability: Azure plans to become climate positive by 2030 which aligns with client’s commitment. AWS’s goal of becoming net-zero carbon is 2040.
* Integration and Compatibility: Azure Cloud makes the integration easier with other products being simpler to use and implement than AWS, which is known for its complexity and big documentation.
* Security: Azure provides several built-in security measures to prevent threats. Azure also provides the Azure AD to simplify the management of user identities, creating a more secure environment data.
* Usability: Azure user interface is perceived more user-friendly, which can simplify management of the cloud and makes the learning progress easier for a new team or team member.

Using containers over VMs is another alternative that could have been used in this project.  
Containers are a cloud-based service that enables developers to encapsulate their code along with the required libraries for streamlined deployment. Since the web solution is of small size, containers would be the better choice since it’s lightweight and consumes fewer resources than VMs, which would have made it more environmental-friendly. However, to purchase a container registry and a container instance for managing containers, this would be more costly as the price is around $5 per month. Also, containers can have risks if the publicly made images have security vulnerabilities.

Regarding authentication method used in this project, I could have used Microsoft OAuth2 Authentication rather than Google OAuth2 since it is a product of Microsoft, and the integration would be easier. However, most users have Google accounts logged in the browser, and this ensures a smoother experience for them.