Provisioning for Azure   
Cost Optimization & Monitoring Project  
 Project Starter Template



STEP 0: Problem Background

Company “X” is an engineering company that has offices in both the US East & West Coast. They currently host all their data and applications in a single East coast data center and are constantly worried about both cost and resiliency. Below is how their current servers are configured.

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| Server(s): | **Purpose:** Windows/Linux Server  **Environment:** Physical Servers  **Operating System:** Windows  **Operating System License:** DataCenter  **Servers:** 10  **Procs per server:** 2  **Core(s) per proc:** 8 Cores  **RAM:** 256 GB  **Optimize By:** CPU  **GPU:** None  **Usage:** These are the servers where all your engineering workloads happen. Currently they all are being leveraged at regular capacity. |
| Server(s): | **Purpose:** Web App  **Environment:** Physical Servers  **Operating System:** Windows  **Operating System License:** DataCenter  **Servers:** 3  **Procs per server:** 1  **Core(s) per proc:** 8 Cores  **RAM:** 64 GB  **Optimize By:** CPU  **GPU:** None  **Usage:** These are the web app servers for your company. Currently they all are being leveraged at regular capacity. |
| Server(s): | **Source:** Database Server  **Database:** Microsoft SQL Server  **License:** Enterprise  **Environment:** Physical Servers  **Operating System:** Windows  **Operating System License:** Datacenter  **Servers:** 3  **Procs per server:** 1  **Cores per proc:** 16 Cores  **RAM:** 64 GB  **Optimize By:** CPU  **Usage:** These three servers are running Microsoft SQL Server and provide the database for your engineering company. It is critical that they are always running.  **Destination**  Service: SQL Database  Purchase Model: vCore  Service Tier: Business Critical  Instance Cores: 2  SQL Server Storage: 5  SQL Server backup: 0 |
| Storage | **Purpose:** Storage  **Type:** Local Disk / SAN  **Disk Type:** HDD  **Capacity:** 1 TB  **Back-Up:** None currently  **Archive:** None |
| Networking | Amount of network bandwidth you currently consume in your on-premises environment: 1 GB |

# **STEP 1: Assessing the On-Premises Environment & Generating Total Cost of Ownership (TCO) Report**

Purpose: To identify the Azure services needed to ensure Company “X”’s business continuity in the cloud.

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| **Current Environment/** **Background**  Make a list of all current on-premises servers and services. | There are 10 Windows VM’s which are used for engineering purposes.  There are 3 web apps servers which host the front end of the company.  There are 3 database servers.  There is a storage which is also used to store data. |
| **Matching Azure Services**  Match the list of on-premises servers and services to the corresponding Azure ones. | Make a list of all servers and services you would create on Azure and explain why you chose each.  **Hint**:   * For VM’s and Web Apps: The operating system license is always Standard and Virtualization is always Hyper-V. * For databases: The purchase model is vCore, the Service Tier is Business Critical, and no SQL Server Backup is needed. * For networking: The defaults of 200 GB for outbound bandwidth are used.     List of resources:   * 10 E32-16as v5 (16 vCPUs, 256 GB RAM) * 3 DC8s v3 (8 vCPUs, 64 GB RAM * Block Blob Storage, General Purpose V2, Flat Namespace, LRS Redundancy, Hot Access Tier, 1 TB Capacity * Internet egress, 200 GB outbound data transfer * Try to create resources as same as current on-prem |
| **Screenshot 1**  Submit the screenshot for each of the above configurations from Azure TCO.  VM and Web Apps Server screenshot should be submitted here. |  |
| **Screenshot 2**  Submit the screenshot for each of the above configurations from Azure TCO.  Database screenshot should be submitted here. |  |
| **Screenshot 3**  Submit the screenshot for each of the above configurations from Azure TCO.  Storage configuration screenshot should be submitted here. |  |
| **Screenshot 4**  Submit the screenshot for each of the above configurations from Azure TCO.  Networking configuration screenshot should be submitted here. |  |
| **Screenshot 5**  Once the TCO Report is generated, submit a screenshot of the price comparison graph (line graph) here. |  |
| **Screenshot 6**  Once the TCO Report is generated, submit a screenshot of the price comparison graph (pie chart) here. |  |
| **Screenshot 7**  Once the TCO Report is generated, submit a screenshot of the price comparison chart (tabular format) here. |  |
| **Explanation 1**  Explain the breakdown of the costs and show your understanding of how on-prem costs versus Azure compare | We can see that using Azure save a huge amount of cost compared to the on-prem  1. Compute Cost   |  |  | | --- | --- | | On-prem | Azure | | Pay for the physical servers which need to be replaced and maintained from time to time with the needs of the organization.  Company is stuck with the purchased hardware. If they want to upgrade, they must sell with lower price or reuse the outdated hardware and buy additional resources for the data center. | No cost for hardware. Maintenance and support cost are included, eliminating annual contracts, and Azure owns up the responsibility of providing the up-to-date hardware to clients. Client don’t have to pay for the maintenance. There are also various payment types such as pay as you go, reservation … | | Have to pay for the license such as OS, software… | Azure Hybrid Benefit is a licensing benefit that helps you do more with less, reducing the costs of running your workloads. It works by letting you use Software Assurance-enabled Windows Server and SQL Server licenses, and RedHat and SUSE Linux subscriptions on virtual machines in Azure. |   2. Data Center Costs   |  |  | | --- | --- | | On-prem | Azure | | Cost to place data center, for maintenance, cooling, operation, … | No Datacenter cost or can say that the cost is included in the bill. | | Electricity costs should be considered since the machine is running 24/24, cooling system, … The price base on the geo location | Electricity costs on azure are lower than on-prem and Azure also use green energy |   3. Networking Cost   |  |  | | --- | --- | | On-prem | Azure | | Cost for ISP, VPN,… Price depends on the provider | Free 100 GB bandwidth per month, a very small amount will be charged for each GB (over 100 GB, price base on geo location), which is cheaper than on-prem. |   4. Storage Cost   |  |  | | --- | --- | | On-prem | Azure | | Hardware cost, need data center, hard to scale, cost to upgrade, operate, maintain… | Cost base on capacity and transactions, easy to scale up or down, up-to-date hardware.  Provide a lot of services with reasonable prices (backup, geo-redundancy) for HA, DR…  Only pay for what you use |   5. IT Labor Cost   |  |  | | --- | --- | | On-prem | Azure | | A lot of things have to be taken care of, need a large number of operators, maintainers… based on the size of the data center | A small number of cloud engineers can operate the cloud infra which help reduce the cost | |

# **STEP 2: Azure Pricing Calculator Cost Estimates**

Purpose: You want to only move the engineering workloads (so just your VM’s) to Azure first to try and understand how Azure cloud works. In addition, this will also help you demonstrate to your CIO that by doing that small migration your company can achieve resiliency. You want to provide precise monthly costs to your CIO.

Use the Azure Pricing Calculator to submit the following screenshots.

**Note:** *If you are using Udacity Cloud Labs, you will be allowed to create a few VM sizes only. Visit*[this](https://portal.azure.com/#create/Microsoft.VirtualMachine) *link to see all possible VM sizes and go through the classroom instructions for more details.*

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| **Task 1** | Matching Azure Services: Match the list of on-premises servers and services to the corresponding Azure ones.  Here is the VM configuration you will pick.   * 5 VM’s will be in US East Coast, and 5 will be in US West Coast. * Choose the instance you want to create in both the regions from the possible VM sizes mentioned in the classroom. * Compute Option will be pay-as-you-go; so, there are no upfront costs. * The default of 730 hours is selected. |
| **Screenshot 1**  Submit the screenshot for each of the above configurations from the Azure Pricing Calculator. Submit the US East Coast monthly costs here. |  |
| **Screenshot 2**  Submit the screenshot for each of the above configurations from the Azure Pricing Calculator. Submit the US **West Coast** monthly costs here. |  |
| **Screenshot 3**  Submit the screenshot for total cost per month for both US East and West Coasts. |  |
| **Explanation 1**  Explain how resilience is built in by moving to Azure | Resiliency is the ability of a system to recover from failures and continue to function. Every technology has its own particular failure modes, which you must consider when designing and implementing your application. Use this checklist to review the resiliency considerations for specific Azure services.  Azure includes built-in reliability services that you can use and manage based on your business needs. Whether it’s a single hardware node failure, a rack level failure, a datacenter outage, or a large-scale regional outage, Azure provides solutions that improve reliability. For example, availability sets ensure that the virtual machines deployed on Azure are distributed across multiple isolated hardware nodes in a cluster. Availability zones protect customers’ applications and data from datacenter failures across multiple physical locations within a region. Regions and availability zones are central to your application design and resiliency strategy.  Since Azure already provided built-in reliability, Azure’s users also have responsibility for the reliability of the platform. Building reliable systems on Azure is a shared responsibility. Microsoft is responsible for the reliability of the cloud platform, which includes its global network and datacenters. Azure customers and partners are responsible for the reliability of their cloud applications, using architectural best practices based on the requirements of each workload.  In this case, by moving to Azure, we created VMs in multiple AZs in different (in this case 2 regions US East and US West Coasts), which makes our services highly available and resilient. For example, if there is an issue which makes all VMs in the US East Coast region down, there’re VMs running in US West Coast, and we can archive zero downtime even an issue happens.  More about Azure reliability: [Azure reliability documentation | Microsoft Learn](https://learn.microsoft.com/en-us/azure/reliability/overview) |

# **STEP 3: Azure Cost Management + Billing**

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| **Background** | You have now configured your Azure Production Workload environment and been using Azure for a few days. You have now been tasked by your CIO to present some metrics on how the costs are being billed within Azure and also what other functionalities Azure has in regards to cost management, which were not previously available. |
| **Question 1**  Submit the explanation | What is the purpose of Azure Cost Mgmt + billing Dashboard? |
| **Explanation 1** | The cost management and billing dashboard is a centralized portal for all cost-optimization insights. You can use these insights to make data-driven decisions on optimizing cloud costs. Azure Advisor also recommends changes in configuration and workloads that could optimize your cloud spend. |
| **Screenshot 2**  Submit the screenshot for main Cost Mgmt + Billing Dashboard. | **Hint:** Navigate to the Cost Management Section on the left and then click “Cost Analysis” to reach this dashboard. Students need to submit the main screenshot of the Billing dashboard |
| **Explanation 2**  Explain the key components of the screenshot submitted. An explanation to be provided for  Scope and Area dropdown from the screenshot submitted. | **Hint**: Make sure the right time period is selected to see the data.   * The area chart shows the cost trending in the appropriately selected date range (Dec 2022) and for the selected scope. This chart can be change to other type of data visualization (line, column, table) by click the Area dropdown. The green is the amount of costs that under the budget threshold, the red color is the amount that exceeded the threshold. * Scope: levels in the resource hierarchy, where one can manage and control access to one or more resources. Starts from Root management group to sub-groups, so one can track various teams. * Area dropdown: change visualization type of the main chart. Available options: Area chart, Line chart, Grouped or Stacked Column, Table. |
| **Screenshot 3**  Submit the screenshot for breakdown of costs by Service Name and Location. | **Hint**: Navigate to Cost Management Section on the left, and then click “Cost Analysis” to reach this dashboard. These pie charts are under the above graph submitted. |
| **Explanation 3**  Explain the key components of the screenshot submitted. | The bottom donut charts show the charges by the certain options:   * Service Name: Costs broken down by service name * Location: Costs broken by region where your Azure infrastructure is stood up * Resource Group Name: Costs broken down by resource group |
| **Screenshot 4**  Submit the screenshot for breakdown of costs by Service Name and Location. | **Hint**: Navigate to Cost Management Section on the left and then click “Cost Alert” to reach this wizard. Next, click on “Add button” on top left under this tab. This is Part 1 of the wizard (of the 2-part process). |
| **Explanation 4**  Explain the key components of the screenshot submitted. | Budgets can be **scoped** in Azure, we can narrow a budget view based on subscription, resource groups, or a collection of resources, etc.  We can also **filter** the resources that will be analyzed by the budget using tags, resource type, resource id, etc.  **Reset period** is the time window analyzed by the budget. At the beginning of each new period the cost evaluated will start at zero. We can create a monthly, quarterly, annual budget and set the maximum threshold for their organization.  **Creation date** is the first day of the first budget evaluation period. Subsequent evaluation periods will begin on the same day of the month moving forward.  **Expiration date** is the day the budget stops evaluating and/or alerting and becomes expired.  **Budget amount** is the threshold that if total cost (scoped and filtered) exceeds its condition (step 2), the budget will send an alert to the configurated emails or trigger the action groups. |
| **Screenshot 5**  Submit the screenshot for breakdown of costs by Service Name and Location | **Hint**: This is Part 2 of the wizard (of the 2-part process). |
| **Explanation 5**  Explain the key components of the screenshot submitted. | Azure provides budgets API to notify one via email (send to the **Alert recipients email**) when a budget **Alert condition** (the **actual/ forecasted** cost exceeds the **% of budget** \* **budget amount**) is satisfied.  We can use Azure Monitor **action groups** to trigger an orchestrated set of actions resulting from a budget event along with sending email. |
| **Screenshot 6**  Submit the screenshot for breakdown of costs by Service Name and Location. | Group by Service Name    Group by Location |
| **Explanation 6**  Explain the key components of the screenshot submitted. | Pic 1: Grouped the costs by Service name, there is no single service that exceed the threshold in Dec 2022  Pic 2: Grouped the costs by Location, the US South Central region has the cost exceeded the threshold (5$) from Dec 27 ($5.02) and beyond |
| **Explanation 7**  Explain the summarized highlights of this part of the project, Azure Cost Mgmt + Billing | Azure Cost Management and Billing is a suite tools that helps users analyze, manage, and optimize the costs. These tools help to ensure the benefits of the cloud are utilized. Azure Cost Management and Billing Dashboard has the following features which help with monitoring cost efficiency:   * Data analysis of costs * Identify opportunities that optimize spending * Alert or trigger actions by setting spending thresholds * Pay bill * Download cost and usage data |

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# **STEP 4: Azure Policy to create and enforce policies**

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| **Background** | You have now configured your Azure Production Workload environment and been using Azure for a few days. You realize that many infrastructure administrators are creating VM sizes without doing proper due diligence, thus having a direct impact on cost.  You now decide to leverage Azure Policy features to ensure that appropriate controls are put in place. |
| **Screenshots 1 through 5**  Submit the screenshots for Azure Policy steps. | **Hint**: Navigate to and select the built-in Azure policy “Allowed virtual machine size SKUs;” then follow the wizard steps. Submit a screenshot for every single step of the wizard so that any mistakes in the final step can be caught by your reviewer.  **Very important note:**   1. Due to lab restrictions, while you go through the wizard, you will not be allowed to create the policy in the final step. Please submit all screenshots though 2. So for the Part 2 of this project to be submitted, a successful policy has already been created in the lab for you, which can be used to test the VM creation scenario. Please ensure to double check which VM series is allowed to be created in the lab and ensure that you do not use the same series for passing this part of the project   **Step 1:**  **Step 2:**  **Step 3**  **Step 4:**    **Step 5:** |
| **Screenshot 6**  Explain through screenshots what happens when you create a VM which is in violation with the policy you just created. | Once the Azure policy creation is complete, try to create a VM which is of a “NOT ALLOWED” size.   **Hint**: pick any size; it doesn’t matter as long as it's not in the allowed list in Azure policy you just created.   Once you go through the wizard, in the final step you will see the following screenshot, which needs to be submitted.    Since the D2as\_v4 size is restricted by policy, the Select button is gray and I cannot select that size, so I cannot continue the next step to create the VM.  If I choose an allowed size, I can create the VM |
| **Explanation 1**  Explain the summarized highlights of this part of the project, Azure Policy. | Azure Policy helps to enforce organizational standards and to assess compliance at scale (in our case we get to restrict admins who are creating VM sizes without considering costs). It provides an aggregated view with the ability to drill down to the per-resource, per-policy granularity.  Policies can be applied at multiple levels and are inherited from top to bottom starting from the root management group up to resource groups. They also help assign policies at the appropriate level to have the right controls for resources. Azure Policy starts with a policy definition with conditions for enforcement. If certain conditions are met, we can Deny, Remediate, or Audit. (In our case we used a Deny Policy) |

**STEP 5: Azure Dashboards**

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| **Background** | Azure Dashboards are a one stop shop to monitor   * Your logs * Your infrastructure * Your applications |
| **Task 1** | You need to create an Azure dashboard that will pull in a few widgets: Percentage CPU, All Resources, Resource Groups & Avg CPU Credits Consumed. Submit the screenshots and explain the key components of the Dashboard. Be sure to include a screenshot of the final Dashboard. |
| **Screenshots1 through 3**  You will submit the screenshots for Overview tab. | **Step 1:**  **Step 2:**      **Step 3 (Final Output):** |

# **STEP 6: Azure Monitor – Metrics**

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| **Task 1** | You need to navigate to Azure Monitor > Metrics screen and create a Percentage CPU as a metric and submit screenshot of the graph generated and pin to dashboard. |
| **Screenshots 1 through 3**  You will submit the screenshots for Monitor | Metrics screen as you are setting up | **Step 1:**    **Step 2:**    **Step 3:**    **\*\* Got a duplicated panel because I already created the same one in Task 1** |
| **Screenshot 4**  Now that Azure Metrics Monitor is configured, please set an alert for that metric. The alert is whenever the Avg % CPU is greater than 0.3; then the alert will be triggered. |  |

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# **STEP 7: Azure Monitor – Log Analytics**

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| **Task 1** | You need to create a Log Analytics workspace and submit step-by-step screenshots. |
| **Screenshots 1 through 4**  You will submit the screenshots for Log Analytics workspace creation screens. | **Step 1:**    **Step 2:**  **Step 3:**  **Step 4:** |

# **STEP 8: Azure Insights**

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| **Background** | Azure Insights can only be created once you have the Log Analytics workspace completed. |
| **Screenshots1 through 6**  You will submit the screenshots for the Monitor | Metrics screen as you are setting up. | **Hint 1:** Navigate to Insights > Applications and then click Add button  **Hint 2:** The Log Analytics workspace you created before will be used here  **Step 1:**  **Step 2:**  **Step 3:**  **Step 4:**  **Step 5:**  **Step 6: Click “Go to resource”** |
| **Screenshots 7 through 12**  **You will submit screenshots of you enabling the VM.** | **Hint 1:** So now that you have created Azure Insights for the Resource group, you need to go to Virtual Machines tab and actually enable it for the VM itself.  **Hint 2:** The key is to select the Log Analytics workspace which you created above in STEP 7:  Azure Monitor – Log Analytics.  **Step 7:**    **Step 8:**  **Step 9:**  **Step 10:**  **Step 11:**  **Step 12:** |

# **STEP 9: Azure Monitor – Smart Alerts**

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| **Task 1** | Navigate to Setup Alert & Actions under Azure Monitor >Overview.  The condition name should be CPU units consumed and its value should be greater than 0.3. |
| **Screenshots 1 through 8**  You will submit step-by-step screenshots for creating a Setup Alert & Actions. | **Step 1:**  **Step 2:**  **Step 3:**  **Step 4:**  **Step 5:**    **Step 6 (Summary after above steps):**    **Step 7 (Screenshot post-creation of the alert):**  **Step 8 (If you had any alerts, they would be submitted here):** |
| **Explanation 1**  Explain the purpose of Azure Dashboards, Azure Monitor and alerts | Azure Dashboards   * A key tool for Solution Architects to monitor operational efficiency. Dashboards are a focused and customized view of your cloud resources and metrics in the Azure portal. * Provides a customized view of your cloud metrics by use of appropriate widgets, a unified place to monitor resources quickly. * Building a custom Dashboard can enable one to quickly consume relevant information, identify issues. * Focused and organized view of your cloud resources in the Azure portal. * Use dashboards as a workspace where you can monitor resources and quickly launch tasks for day-to-day operations and can build custom dashboards based on projects, tasks, or user roles etc. * The Azure portal provides a default dashboard as a starting point, we can also edit the default dashboard and create and customize additional dashboards.   Azure Monitor   * Azure Monitor helps you maximize the availability and performance of your applications and services. * It delivers a comprehensive solution for collecting, analyzing, and acting on telemetry from your cloud and on-premises environments. * This information helps you understand how your applications are performing and proactively identify issues that affect them and the resources they depend on.   Azure Monitor Alerts   * Alerts help you detect and address issues before users notice them by proactively notifying you when Azure Monitor data indicates that there may be a problem with your infrastructure or application. * You can alert on any metric or log data source in the Azure Monitor data platform. |

# **STEP 10: Autoscale In-Out Based on Number of Users per CPU Core**

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| **Task 1** | The lab will have a Virtual Machine Scale set already created.  Navigate to Azure Monitor > Settings > Autoscale.  You will create an Autoscale rule as part of this project. |
| **Screenshots 1-5**  You will submit step-by-step screenshots for creating an autoscale rule under Azure Monitor. | **Step 1 (Browse to Monitor > Autoscale):**  **Step 2 (Select the option for Custom autoscale and within that Scale based on metric and then click “Add Rule”):**  **Step 3 (Create the scale rule. They key part on this screen is that Percentage CPU metric is selected):**    **Step 4 (Once scale rule is created, submit the summary screenshot):**  **Step 5 (Screenshot for “Autoscale Enabled”):** |
| **Explanation 1**  Explain the key details of autoscale screenshots you have submitted. | AutoScale can be done manually or via customization.  There’re 2 choices   * Scale based on metric * Scale to specific instance count, autoscale based on a schedule   We choose scale based on metric count   * Leverage metrics such as % CPU to scale out or scale in   We Add a rule for metric based scale in/out   * Time Aggregation as Average is selected - so the scale is applied to the average metric instead of min/max. * Metric Name: Percentage CPU * Operator such as Greater than is selected can be other operators as well   based on requirement.   * Most importantly metric threshold to trigger scale action is then entered which in this case is 5%.   Other defaults such as duration and cool down period are set as per suggested by  Azure  (Cool down means once one this custom scale has triggered wait for at least 5 mins in our case to trigger another custom scale rule trigger is detected)  Min, Max, default are instance parameters (provided by default by azure but customizable):   * Can go to Min no of 2 VMs in case of scale in * Can go to Max no of 2 VMs in case of scale out (since we already have 2 VMs we wont scale up even if rule is triggered) * Default is 2 |