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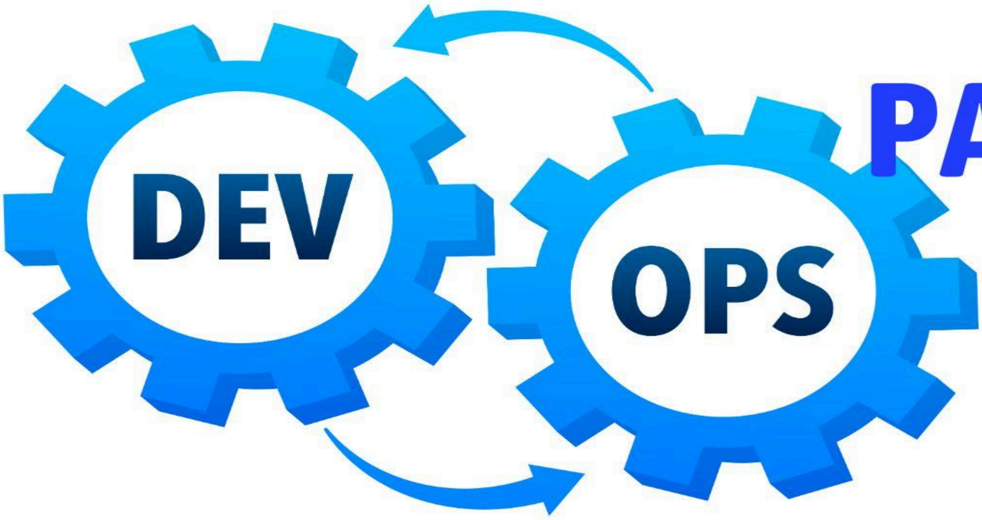
PART 2



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Project 1: Azure DevOps Pipeline for Automated Database Schema Deployment

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1. Project Scope

This project focuses on automating the deployment of database schema updates using **Azure DevOps Pipelines**. When a developer updates the database schema (e.g., adding a new column, modifying a table), the pipeline will automatically validate and apply the changes to the database.

Key Features:

✅ Automate database schema changes with version control
✅ Ensure safe deployments with pre-deployment validation
✅ Implement rollback in case of failure
✅ Improve collaboration between Dev and DB teams
✅ Ensure consistency across environments (Dev, QA, Staging, Prod)

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2. Tools Used

- **Azure DevOps Pipelines** – Automates the deployment process
- **Azure SQL Database** – Target database for schema changes
- **SQL Server Data Tools (SSDT)** – Schema validation
- **DACPAC (Data-tier Application Package)** – Schema deployment format
- **SQLCMD** – Executes SQL scripts
- **Azure Key Vault** – Securely stores database credentials
- **PowerShell** – Automates database operations

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3. Analysis Approach

Challenges Without Automation

❌ Manual schema updates can introduce errors
❌ Developers may forget to apply updates to all environments
❌ Schema drift (inconsistencies across databases)
❌ Rollback is time-consuming

Proposed Solution

✅ Use Azure DevOps Pipelines to automate schema deployment
✅ Validate SQL scripts before applying them
✅ Implement rollback strategy for failed deployments
✅ Use DACPAC to track schema changes and maintain consistency

4. Step-by-Step Implementation

Step 1: Create an Azure DevOps Repository

1. Go to **Azure DevOps** → **Repos** → **New Repository**
2. Clone the repo and create a `Database` folder
3. Add a sample SQL project (`.sqlproj`)

Step 2: Develop and Store SQL Scripts

1. Inside the `Database` folder, create:
   - `Tables/Users.sql`
   - `Tables/Orders.sql`
   - `Procedures/UpdateUserDetails.sql`
2. Use SQL Server Data Tools (SSDT) to package `.sqlproj` into a **DACPAC** file

Step 3: Create a CI Pipeline for SQL Validation

1. Navigate to **Azure DevOps** → **Pipelines** → **New Pipeline**
2. Choose **Azure Repos Git**
3. Add the following YAML for schema validation:

```
Unset
trigger:

  branches:

    include:

      - main


pool:

  vmImage: 'windows-latest'


steps:

- task: VSBuild@1

  displayName: 'Build SQL Database Project'
```

```
  inputs:

    solution: '**/*.sqlproj'

    platform: 'Any CPU'

    configuration: 'Release'


- task: PublishBuildArtifacts@1

  displayName: 'Publish DACPAC File'

  inputs:

    pathToPublish: '$(Build.ArtifactStagingDirectory)'

    artifactName: 'DACPAC'
```

Step 4: Create a CD Pipeline for Deployment

1. Go to **Azure DevOps** → **Releases** → **New Release Pipeline**
2. Select **Azure SQL Database Deployment**
3. Configure the task with:
    - **Azure Subscription:** Link your Azure account
    - **Database Type:** Azure SQL Database
    - **Deploy Method:** DACPAC
4. Modify the pipeline YAML:

Unset
```
trigger:

  branches:

    include:

      - main



pool:
```

```
  vmImage: 'windows-latest'


steps:
- task: SqlAzureDacpacDeployment@1
  inputs:
    azureSubscription: 'MyAzureSubscription'
    serverName: 'mydatabase.database.windows.net'
    databaseName: 'MyDB'
    authenticationType: 'servicePrincipal'
    dacpacFile: '$(Build.ArtifactStagingDirectory)/DACPAC/*.dacpac'
```

Step 5: Implement Rollback Strategy

If deployment fails:

- Restore the previous DACPAC using:

```
Unset
sqlpackage.exe /Action:Publish
/SourceFile:"$(Build.ArtifactStagingDirectory)/PreviousDACPAC.dacpac"
```

---

5. Conclusion

🚀 **Key Benefits of Automated Database Deployment:** ✅ No manual intervention needed
✅ Schema remains consistent across environments
✅ Reduced risk of human error
✅ Easy rollback in case of issues

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6. Real-Time Example

A **financial services company** with multiple databases can use this approach to ensure **schema consistency**, prevent manual errors, and **deploy changes securely** without downtime.

Project 2: Implementing Secure DevOps with Azure Policy and Compliance as Code

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1. Project Scope

This project focuses on **automating security compliance** using **Azure Policy and Compliance as Code** within **Azure DevOps Pipelines**. The goal is to enforce security rules across cloud resources, ensuring that every deployment follows organizational policies.

Key Features:

✅ **Automate compliance checks** for Azure resources
✅ **Prevent non-compliant deployments**
✅ **Use Azure DevOps Pipelines** to apply policies automatically
✅ **Monitor compliance in real-time**
✅ **Ensure governance across multiple subscriptions**

---

2. Tools Used

- **Azure Policy** - Defines and enforces compliance rules
- **Azure DevOps Pipelines** - Automates policy deployment
- **Azure CLI / PowerShell** - Manages policy definitions
- **Azure Monitor & Compliance Center** - Tracks violations
- **Terraform / Bicep** - Deploys policies as code
- **Azure Key Vault** - Stores secure credentials

---

3. Analysis Approach

Challenges Without Compliance Automation

❌ Cloud misconfigurations lead to security risks
❌ Developers may deploy resources without following security guidelines
❌ Manual audits are time-consuming and error-prone
❌ Lack of **visibility** into non-compliant resources

Proposed Solution

✅ Use **Azure Policy as Code** to enforce security best practices
✅ Integrate **Azure DevOps Pipelines** to apply policies at every deployment
✅ Monitor violations using **Azure Security Center**
✅ Automate **remediation** for non-compliant resources

---

4. Step-by-Step Implementation

Step 1: Create a Policy Definition in Azure

1. Open **Azure Portal** → **Policy**
2. Click **Definitions** → **Add Policy Definition**
3. Use the following JSON to prevent public IP creation:

```
Unset
{
  "mode": "All",
  "policyRule": {
    "if": {
      "field":
"Microsoft.Network/publicIPAddresses/publicIPAllocationMethod",
      "equals": "Static"
    },
    "then": {
      "effect": "Deny"
    }
  }
}
```

4. Click **Save** and **Assign Policy** to a Subscription.

Step 2: Automate Policy Deployment Using Bicep in Azure DevOps

1. Create a **Bicep file (`policy.bicep`)** for policy definition:

Unset

```
resource policyDef
'Microsoft.Authorization/policyDefinitions@2020-09-01' = {

  name: 'deny-public-ip'

  properties: {

    displayName: 'Deny Public IP'

    policyType: 'Custom'

    mode: 'All'

    policyRule: {

      if: {

        field:
'Microsoft.Network/publicIPAddresses/publicIPAllocationMethod'

        equals: 'Static'

      }

      then: {

        effect: 'Deny'

      }

    }

  }

}
```

Step 3: Create an Azure DevOps Pipeline for Policy Deployment

1. Navigate to **Azure DevOps** → **Pipelines** → **New Pipeline**
2. Select **Azure Repos Git**
3. Create a new **YAML pipeline**:

Unset
```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

steps:
- task: AzureCLI@2
  displayName: 'Deploy Policy using Bicep'
  inputs:
    azureSubscription: 'MyAzureSubscription'
    scriptType: 'bash'
    scriptLocation: 'inlineScript'
    inlineScript: |
      az deployment sub create --location eastus --template-file
policy.bicep
```

Step 4: Validate Policy Enforcement

1. **Test non-compliance** by trying to create a public IP manually:

Unset

```
az network public-ip create --resource-group MyRG --name MyPublicIP
--allocation-method Static
```

2. If the policy is applied correctly, **Azure will deny the request**.

Step 5: Automate Compliance Reporting

1. Enable **Azure Monitor Logs** to track violations:

Unset

```
az policy state list --query "[?complianceState=='NonCompliant']"
```

2. Send alerts when non-compliance is detected using **Azure Monitor**.

---

5. Conclusion

🚀 **Key Benefits of Azure Policy Automation:**
✅ **Prevents security misconfigurations before deployment**
✅ **Ensures compliance with organizational policies**
✅ **Automates policy enforcement with DevOps workflows**
✅ **Provides real-time monitoring and alerts for violations**

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6. Real-Time Example

A **healthcare company** handling sensitive data can use **Azure Policy as Code** to enforce **HIPAA compliance**, ensuring that no resources expose data to the public cloud.

Project 3: Implementing Multi-Stage CI/CD Pipeline with Azure DevOps for Microservices Deployment

---

1. Project Scope

This project focuses on setting up a **multi-stage CI/CD pipeline** in **Azure DevOps** to deploy a **microservices-based application** to **Azure Kubernetes Service (AKS)**. Each microservice will be built, tested, and deployed **independently** using a **multi-stage pipeline**.

Key Features:

✅ **Automate build, test, and deployment** of microservices
✅ **Use Docker & Kubernetes** for containerized deployment
✅ **Implement Canary & Rolling updates**
✅ **Manage configurations with Helm**
✅ **Secure secrets using Azure Key Vault**

---

2. Tools Used

- **Azure DevOps Pipelines** - Automate CI/CD
- **Azure Kubernetes Service (AKS)** - Host containerized microservices
- **Docker & Azure Container Registry (ACR)** - Store images
- **Helm** - Manage Kubernetes deployments
- **Azure Key Vault** - Store sensitive configurations
- **Prometheus & Grafana** - Monitor microservices

---

3. Analysis Approach

Challenges Without a Multi-Stage Pipeline

❌ Microservices deployments are inconsistent
❌ Manual testing increases deployment delays
❌ Lack of automated rollback increases downtime
❌ Security risks due to hardcoded secrets

Proposed Solution

✅ Implement a **multi-stage pipeline** with **separate build, test, and deploy stages**
✅ Automate deployment using **Helm & Kubernetes**
✅ Secure configurations using **Azure Key Vault**
✅ Enable **rolling updates** for zero downtime

---

4. Step-by-Step Implementation

Step 1: Create an AKS Cluster

1. **Provision an Azure Kubernetes Service (AKS) Cluster:**

```
Unset
az group create --name MyResourceGroup --location eastus

az aks create --resource-group MyResourceGroup --name MyAKSCluster
--node-count 3 --generate-ssh-keys
```

2. **Connect to AKS Cluster:**

```
Unset
az aks get-credentials --resource-group MyResourceGroup --name
MyAKSCluster
```

Step 2: Set Up Azure DevOps Repository & Docker Configuration

1. **Create a repository in Azure DevOps**
2. **Add microservices source code** (`/microservices/user-service/`, `/microservices/order-service/`)
3. **Create a Dockerfile for each microservice** (Example: `user-service/Dockerfile`):

```
Unset
FROM node:14

WORKDIR /app

COPY package.json .

RUN npm install

COPY . .

CMD ["node", "server.js"]
```

4. **Push code to Azure Repos:**

```
git add .

git commit -m "Initial commit"

git push origin main
```

Step 3: Implement CI Pipeline for Building & Pushing Docker Images

1. **Go to Azure DevOps → Pipelines → New Pipeline**
2. **Create a YAML pipeline (`ci-pipeline.yml`):**

```
trigger:

  branches:

    include:

      - main



pool:

  vmImage: 'ubuntu-latest'



stages:

- stage: Build

  jobs:

  - job: Build

    steps:

    - task: Docker@2

      inputs:
```

```
        command: 'buildAndPush'
        repository: 'myacr.azurecr.io/user-service'
        dockerfile: 'microservices/user-service/Dockerfile'
        containerRegistry: 'MyAzureContainerRegistry'
        tags: '$(Build.BuildId)'

    - task: Docker@2
      inputs:
        command: 'buildAndPush'
        repository: 'myacr.azurecr.io/order-service'
        dockerfile: 'microservices/order-service/Dockerfile'
        containerRegistry: 'MyAzureContainerRegistry'
        tags: '$(Build.BuildId)'
```

Step 4: Implement CD Pipeline for Microservices Deployment

1. **Create a Kubernetes Deployment YAML (`k8s-deployment.yaml`):**

```
Unset
apiVersion: apps/v1
kind: Deployment
metadata:
  name: user-service
spec:
```

```
  replicas: 2
  selector:
    matchLabels:
      app: user-service
  template:
    metadata:
      labels:
        app: user-service
    spec:
      containers:
      - name: user-service
        image: myacr.azurecr.io/user-service:latest
        ports:
        - containerPort: 3000
```

2. **Modify the CD pipeline (`cd-pipeline.yml`):**

Unset
```
trigger:
  branches:
    include:
      - main


pool:
```

```
  vmImage: 'ubuntu-latest'


stages:
- stage: Deploy
  jobs:
  - job: Deploy
    steps:
    - task: Kubernetes@1
      inputs:
        connectionType: 'Azure Resource Manager'
        azureSubscription: 'MyAzureSubscription'
        azureResourceGroup: 'MyResourceGroup'
        kubernetesCluster: 'MyAKSCluster'
        namespace: 'default'
        command: 'apply'
        useConfigurationFile: true
        configuration: 'k8s-deployment.yaml'
```

Step 5: Secure Secrets Using Azure Key Vault

1. **Create an Azure Key Vault:**

Unset
```
az keyvault create --name MyKeyVault --resource-group MyResourceGroup
--location eastus
```

2. **Store API keys and database credentials:**

```
Unset
az keyvault secret set --vault-name MyKeyVault --name
"DBConnectionString" --value "Server=myserver;Database=mydb;"
```

3. **Modify Kubernetes deployment to use secrets:**

```
Unset
env:

- name: DB_CONNECTION_STRING

  valueFrom:

    secretKeyRef:

      name: azure-keyvault

      key: DBConnectionString
```

Step 6: Implement Rolling Updates & Rollback

1. **Enable rolling updates in Kubernetes:**

```
Unset
strategy:

  type: RollingUpdate

  rollingUpdate:

    maxUnavailable: 1

    maxSurge: 1
```

2. **Rollback if needed:**

Unset
```
kubectl rollout undo deployment user-service
```

---

5. Conclusion

🚀 **Key Benefits of Multi-Stage CI/CD Pipeline for Microservices:**
✅ **Automates deployments** across multiple environments
✅ **Enables faster releases with minimal downtime**
✅ **Enhances security by managing secrets centrally**
✅ **Improves scalability with Kubernetes**

---

6. Real-Time Example

A **large e-commerce platform** deploying multiple microservices (cart, orders, payments) can use **Azure DevOps Pipelines** to ensure **continuous delivery** with **zero downtime**.

Project 4: Implementing Azure DevOps CI/CD Pipeline for Infrastructure as Code (IaC) using Bicep

---

1. Project Scope

This project focuses on **Infrastructure as Code (IaC) with Bicep** to automate the provisioning and management of **Azure resources** using **Azure DevOps Pipelines**. Instead of using ARM templates, Bicep provides a **simpler syntax** while still leveraging Azure's native deployment capabilities.

Key Features:

✅ **Automate Infrastructure Deployment using Bicep**
✅ **Manage Infrastructure as Code (IaC) in Azure DevOps**
✅ **Implement Role-Based Access Control (RBAC) policies**
✅ **Ensure consistency across environments (Dev, QA, Prod)**
✅ **Enable rollback in case of failed deployments**

---

2. Tools Used

- **Azure DevOps Pipelines** – Automate deployments
- **Bicep** – Declarative IaC language for Azure
- **Azure CLI** – Manages Azure resources via scripts
- **Azure Key Vault** – Securely stores credentials
- **Azure Storage Account** – Stores deployment logs
- **PowerShell & YAML** – Automation scripting

---

3. Analysis Approach

Challenges Without Infrastructure as Code (IaC)

❌ Manual deployments are **error-prone** and time-consuming
❌ Difficult to **track** changes in infrastructure
❌ No **version control**, making rollback difficult
❌ Security risks due to **hardcoded credentials**

Proposed Solution

✅ Define **Azure infrastructure** as code using Bicep
✅ Automate **resource provisioning** via Azure DevOps
✅ Use **RBAC policies** to ensure secure deployments
✅ Store **secrets in Azure Key Vault**

---

4. Step-by-Step Implementation

Step 1: Create an Azure DevOps Repository for Bicep Code

1. Go to **Azure DevOps** → **Repos** → **New Repository**
2. Clone the repo and create a new directory:

```
Unset
git clone https://dev.azure.com/MyOrg/BicepDeployment.git

cd BicepDeployment

mkdir bicep-files
```

3. Inside the `bicep-files` folder, create a **Bicep template (`main.bicep`)** to deploy an Azure Storage Account:

```
Unset
resource storageAccount 'Microsoft.Storage/storageAccounts@2021-09-01'
= {

  name: 'myuniquestorageaccount'

  location: 'East US'

  sku: {

    name: 'Standard_LRS'

  }

  kind: 'StorageV2'

}
```

4. Commit and push the code to Azure Repos:

```
Unset
git add .

git commit -m "Added Bicep template"
```

```
git push origin main
```

Step 2: Configure an Azure DevOps CI Pipeline for Bicep Validation

1. Go to **Azure DevOps** → **Pipelines** → **New Pipeline**
2. Select **Azure Repos Git** as the source
3. Create a new **YAML pipeline** (**`bicep-ci.yml`**):

Unset
```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

steps:
- task: AzureCLI@2
  displayName: 'Validate Bicep Template'
  inputs:
    azureSubscription: 'MyAzureSubscription'
    scriptType: 'bash'
    scriptLocation: 'inlineScript'
    inlineScript: |
```

```
az bicep build --file bicep-files/main.bicep
```

4. **Run the pipeline** to validate the Bicep syntax.

Step 3: Create an Azure DevOps CD Pipeline for Deployment

1. Navigate to **Azure DevOps** → **Pipelines** → **New Release Pipeline**
2. Select **Azure Resource Group Deployment**
3. Modify the pipeline YAML (`bicep-cd.yml`) for deployment:

Unset
```
trigger:

  branches:

    include:

      - main


pool:

  vmImage: 'ubuntu-latest'


steps:

- task: AzureCLI@2

  displayName: 'Deploy Bicep Template'

  inputs:

    azureSubscription: 'MyAzureSubscription'

    scriptType: 'bash'

    scriptLocation: 'inlineScript'
```

```
    inlineScript: |
      az deployment group create --resource-group MyResourceGroup
--template-file bicep-files/main.bicep
```

4. **Run the pipeline** to deploy resources automatically.

Step 4: Secure Infrastructure Using Azure Key Vault

1. **Create an Azure Key Vault:**

```
Unset
az keyvault create --name MyKeyVault --resource-group MyResourceGroup
--location eastus
```

2. **Store sensitive credentials in Key Vault:**

```
Unset
az keyvault secret set --vault-name MyKeyVault --name
"StorageAccountKey" --value "my-secure-key"
```

3. **Modify Bicep to retrieve secrets from Key Vault:**

```
Unset
param storageKey string =
resourceId('Microsoft.KeyVault/vaults/secrets', 'MyKeyVault',
'StorageAccountKey')
```

Step 5: Implement Role-Based Access Control (RBAC) Policies

1. **Assign "Contributor" role to DevOps pipeline:**

```
Unset
az role assignment create --assignee "<pipeline-service-principal>"
--role Contributor --scope
"/subscriptions/<subscription-id>/resourceGroups/MyResourceGroup"
```

2. **Modify Bicep to enforce RBAC roles:**

```
Unset
resource roleAssignment
'Microsoft.Authorization/roleAssignments@2020-10-01-preview' = {

  name: guid('MyResourceGroup', 'Contributor')

  properties: {

    roleDefinitionId:
'/providers/Microsoft.Authorization/roleDefinitions/<role-id>'

    principalId: '<pipeline-service-principal>'

  }

}
```

Step 6: Implement Rollback in Case of Failed Deployment

1. **Use Azure Deployment History to track changes:**

```
Unset
az deployment group show --resource-group MyResourceGroup --name latest
```

2. **Rollback to previous version if deployment fails:**

```
Unset
az deployment group create --resource-group MyResourceGroup --mode
Complete --template-file previous-template.bicep
```

---

5. Conclusion

🚀 **Key Benefits of Bicep for IaC in Azure DevOps:**
✅ **Simplifies Infrastructure as Code** with an easy syntax
✅ **Ensures consistent deployments** across multiple environments
✅ **Secures credentials** using **Azure Key Vault**
✅ **Provides rollback capabilities** for failed deployments

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6. Real-Time Example

A **financial services company** managing multiple Azure environments (Dev, Staging, Prod) can use **Bicep with Azure DevOps** to **automate and standardize** infrastructure deployments while ensuring **security and compliance**.

Project 5: Implementing Azure DevOps Pipeline for Automated Security Scanning using SonarQube and WhiteSource

---

1. Project Scope

This project focuses on integrating **automated security scanning** into an **Azure DevOps CI/CD pipeline** using **SonarQube** for code quality analysis and **WhiteSource (Mend)** for open-source dependency security checks.

Key Features:

✅ **Identify vulnerabilities early** in the development lifecycle
✅ **Enforce code quality** using **SonarQube**
✅ **Scan for security vulnerabilities** in open-source dependencies using **WhiteSource**
✅ **Prevent insecure code from being deployed**
✅ **Generate reports for auditing and compliance**

---

2. Tools Used

- **Azure DevOps Pipelines** – Automates the security scanning process
- **SonarQube** – Performs static code analysis
- **WhiteSource (Mend)** – Scans for open-source security vulnerabilities
- **Azure Key Vault** – Stores sensitive API keys
- **Azure Artifacts** – Securely stores scanned and approved builds
- **OWASP Dependency-Check** – Identifies known vulnerabilities in dependencies

---

3. Analysis Approach

Challenges Without Security Scanning

❌ **Vulnerabilities** may exist in deployed applications
❌ No **automated enforcement** of security best practices
❌ **Insecure dependencies** could introduce risks
❌ Lack of **visibility** into application security

Proposed Solution

✅ **Automate security scanning** for every code commit
✅ **Block builds if security issues** are found
✅ **Monitor security posture** using SonarQube dashboards
✅ **Ensure compliance with security policies**

---

4. Step-by-Step Implementation

Step 1: Set Up SonarQube in Azure DevOps

1. **Install SonarQube Extension:**
    - Go to **Azure DevOps** → **Extensions Marketplace**
    - Search for **SonarQube** and install it
2. **Create a SonarQube Server in Azure:**
    - Deploy SonarQube using **Azure Container Instances:**

```
az container create --resource-group SecurityRG --name SonarQubeServer \

--image sonarqube --cpu 2 --memory 4 \

--ports 9000 --restart-policy Always
```

3. **Generate a SonarQube Token:**
    - Login to `http://<SonarQubeServer-IP>:9000`
    - Navigate to **Administration** → **Security** → **Generate Token**
4. **Store SonarQube Token in Azure Key Vault:**

```
az keyvault secret set --vault-name SecurityVault --name SonarQubeToken --value "<generated-token>"
```

Step 2: Add SonarQube Scanning to Azure DevOps Pipeline

1. **Go to Azure DevOps** → **Pipelines** → **New Pipeline**
2. **Modify the CI/CD pipeline (`sonar-pipeline.yml`):**

```
trigger:

  branches:
```

```
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

variables:
  sonarToken: $(SONARQUBE_TOKEN)

steps:
- task: SonarQubePrepare@4
  inputs:
    SonarQube: 'MySonarQubeService'
    scannerMode: 'CLI'
    configMode: 'manual'
    cliProjectKey: 'my-security-project'
    cliProjectName: 'SecureApp'
    cliSources: 'src'
    cliArguments: '-Dsonar.token=$(sonarToken)'

- task: SonarQubeAnalyze@4
  displayName: 'Run SonarQube Analysis'
```

```
- task: SonarQubePublish@4

  displayName: 'Publish SonarQube Results'

  inputs:

    pollingTimeoutSec: '300'
```

Step 3: Add Open-Source Vulnerability Scanning with WhiteSource

1. **Install the WhiteSource Bolt Extension in Azure DevOps**
2. **Modify pipeline to include WhiteSource security scan (`whitesource-pipeline.yml`):**

Unset
```
trigger:

  branches:

    include:

      - main


pool:

  vmImage: 'ubuntu-latest'


steps:

- task: WhiteSource@21

  displayName: 'Run WhiteSource Scan'

  inputs:

    cwd: '$(Build.SourcesDirectory)'

    productName: 'SecureApp'
```

```
    configFile: 'whitesource.config.json'
```

3. **Configure WhiteSource Policy** to block builds for high-severity vulnerabilities.

Step 4: Implement Dependency Scanning with OWASP Dependency-Check

1. **Add OWASP Dependency-Check to the pipeline:**

```
Unset
- task: Bash@3
  displayName: 'Run OWASP Dependency Check'
  inputs:
    targetType: 'inline'
    script: |
      curl -sSL https://get.owasp.org/dependency-check-cli/ -o dependency-check.sh
      chmod +x dependency-check.sh
      ./dependency-check.sh --project SecureApp --scan $(Build.SourcesDirectory)
```

Step 5: Block Deployment if Security Issues Are Found

1. **Add a Quality Gate Check in Azure DevOps:**
   - Go to **Azure DevOps** → **Pipelines** → **Releases** → **Pre-deployment Conditions**
   - Enable **Gates** → **Query SonarQube Quality Gate**
   - Set condition to **Fail deployment if security score < 80%**

Step 6: Automate Security Reports & Alerts

1. **Send alerts if vulnerabilities are found:**

Unset

```
az monitor metrics alert create --name "HighSeverityAlert"
--resource-group SecurityRG \

--condition "severity > 3" --action-group "SecOpsTeam"
```

---

5. Conclusion

🚀 **Key Benefits of Security Scanning in Azure DevOps:**
✅ **Automates vulnerability detection** in code and dependencies
✅ **Prevents insecure code from being deployed**
✅ **Enforces security policies using WhiteSource & OWASP checks**
✅ **Improves compliance for organizations following security standards**

---

6. Real-Time Example

A **banking institution** building an online payment system can integrate **SonarQube and WhiteSource in Azure DevOps** to **detect vulnerabilities early** and **ensure compliance with PCI-DSS standards**.

Project 6: Implementing Azure DevOps CI/CD Pipeline for Serverless Applications Using Azure Functions

---

1. Project Scope

This project focuses on **automating the deployment of serverless applications** using **Azure DevOps Pipelines** and **Azure Functions.** Serverless computing enables **event-driven, scalable applications** without managing infrastructure.

Key Features:

✅ **Automate CI/CD for Azure Functions**
✅ **Use Azure DevOps Pipelines for Continuous Deployment**
✅ **Manage Function App configurations using Azure App Configuration**
✅ **Enable monitoring and logging with Azure Application Insights**
✅ **Secure environment variables using Azure Key Vault**

---

2. Tools Used

- **Azure DevOps Pipelines** - Automates deployment
- **Azure Functions** - Serverless compute platform
- **Azure Storage Account** - Event trigger storage
- **Azure Key Vault** - Stores API keys and secrets
- **Azure Application Insights** - Logs and monitors function executions
- **PowerShell & YAML** - Automates infrastructure provisioning

---

3. Analysis Approach

Challenges Without CI/CD for Azure Functions

❌ **Manual deployments** introduce inconsistencies
❌ **Difficult to track code changes** for functions
❌ **No version control** for function configurations
❌ **Security risks** due to hardcoded secrets

Proposed Solution

✅ Automate **Azure Functions deployment** using **Azure DevOps Pipelines**
✅ **Centralize configuration management** using **Azure App Configuration**
✅ Secure API keys and database credentials using **Azure Key Vault**
✅ Enable **monitoring & logging** with **Azure Application Insights**

---

4. Step-by-Step Implementation

Step 1: Create an Azure Function App

1. **Provision an Azure Function App using CLI:**

Unset
```
az group create --name FunctionAppRG --location eastus

az storage account create --name functionstorage --resource-group
FunctionAppRG --location eastus --sku Standard_LRS

az functionapp create --name MyFunctionApp --storage-account
functionstorage --resource-group FunctionAppRG
--consumption-plan-location eastus --runtime python
```

Step 2: Store Configuration in Azure Key Vault

1. **Create an Azure Key Vault:**

Unset
```
az keyvault create --name FunctionAppKeyVault --resource-group
FunctionAppRG --location eastus
```

2. **Store a connection string in the Key Vault:**

Unset
```
az keyvault secret set --vault-name FunctionAppKeyVault --name
"DBConnectionString" --value
"Server=myserver.database.windows.net;Database=mydb;"
```

Step 3: Develop and Push an Azure Function to Azure Repos

1. **Clone the Azure Repos Git Repository:**

Unset
```
git clone https://dev.azure.com/MyOrg/FunctionAppRepo.git

cd FunctionAppRepo
```

2. **Create a sample Python function (`HttpTrigger/__init__.py`):**

Python
```python
import logging

import azure.functions as func



def main(req: func.HttpRequest) -> func.HttpResponse:

    logging.info("Azure Function triggered successfully.")

    return func.HttpResponse("Hello, Azure Serverless World!",
status_code=200)
```

3. **Commit and push the code:**

Unset
```
git add .

git commit -m "Added Azure Function"

git push origin main
```

Step 4: Configure CI Pipeline for Function App Deployment

1. **Navigate to Azure DevOps → Pipelines → New Pipeline**
2. **Create the following YAML file (`azure-functions-ci.yml`):**

Unset
```
trigger:
```

```yaml
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

steps:
- task: UsePythonVersion@0
  inputs:
    versionSpec: '3.x'
    addToPath: true

- script: |
    python -m venv env
    source env/bin/activate
    pip install -r requirements.txt
  displayName: 'Install Dependencies'

- task: ArchiveFiles@2
  inputs:
    rootFolderOrFile: '$(Build.SourcesDirectory)'
    includeRootFolder: false
```

```
    archiveType: 'zip'

    archiveFile: '$(Build.ArtifactStagingDirectory)/function.zip'


- task: PublishBuildArtifacts@1

  inputs:

    pathToPublish: '$(Build.ArtifactStagingDirectory)/function.zip'

    artifactName: 'drop'
```

Step 5: Configure CD Pipeline for Function Deployment

1. Go to Azure DevOps → Releases → New Release Pipeline
2. Select "Azure Function App Deployment"
3. Modify the CD pipeline (`azure-functions-cd.yml`):

```
Unset
trigger:

  branches:

    include:

      - main


pool:

  vmImage: 'ubuntu-latest'


steps:

- task: DownloadBuildArtifacts@0
```

```
  inputs:
    artifactName: 'drop'
    downloadPath: '$(System.DefaultWorkingDirectory)'

- task: AzureFunctionApp@1
  inputs:
    azureSubscription: 'MyAzureSubscription'
    appType: 'functionApp'
    appName: 'MyFunctionApp'
    package: '$(System.DefaultWorkingDirectory)/drop/function.zip'
```

Step 6: Secure API Keys and Configurations

1. **Modify function to fetch secrets from Azure Key Vault (`function.json`):**

Unset
```
{
  "bindings": [
    {
      "type": "httpTrigger",
      "direction": "in",
      "authLevel": "function",
      "methods": ["get"]
    }
```

```
  ],
  "scriptFile": "__init__.py",
  "env": {
    "DB_CONNECTION_STRING":
"@Microsoft.KeyVault(SecretUri=https://FunctionAppKeyVault.vault.azure.
net/secrets/DBConnectionString/)"
  }
}
```

Step 7: Enable Monitoring with Azure Application Insights

1. **Enable Application Insights for Function App:**

Unset
```
az functionapp update --name MyFunctionApp --resource-group
FunctionAppRG --set appInsightsEnabled=true
```

2. **Modify pipeline to enable logging:**

Unset
```
- task: AzureCLI@2
  inputs:
    azureSubscription: 'MyAzureSubscription'
    scriptType: 'bash'
    scriptLocation: 'inlineScript'
    inlineScript: |
      az monitor app-insights component create --app
MyFunctionAppInsights --location eastus --resource-group FunctionAppRG
```

Step 8: Validate and Deploy

1. **Run the Azure DevOps pipeline to deploy the function**
2. **Test the function using cURL:**

Unset
```
curl
https://myfunctionapp.azurewebsites.net/api/HttpTrigger?code=<function-key>
```

3. **Verify logs in Application Insights**

---

5. Conclusion

🚀 **Key Benefits of CI/CD for Serverless Apps in Azure DevOps:**
✅ **Automates Azure Function deployment** for rapid releases
✅ **Secures function configurations** using **Azure Key Vault**
✅ **Improves monitoring** with **Application Insights**
✅ **Reduces costs** by utilizing **serverless architecture**

---

6. Real-Time Example

A **logistics company** can use **Azure Functions with DevOps Pipelines** to automate order processing **without provisioning servers**, ensuring **cost efficiency and scalability**.

Project 7: Implementing Blue-Green Deployment for an Azure Web App Using Azure DevOps

---

1. Project Scope

This project focuses on implementing a **Blue-Green Deployment strategy** using **Azure DevOps Pipelines** and **Azure App Service Deployment Slots**. The **Blue-Green** model reduces downtime and risk by maintaining **two identical environments**, where one serves **live traffic (Blue)** while the other acts as **staging (Green)** for testing.

Key Features:

✅ **Zero-downtime deployments** for web applications
✅ **Instant rollback to the previous version** if issues occur
✅ **Use Azure DevOps Pipelines to automate deployments**
✅ **Route production traffic safely using Azure Traffic Manager**
✅ **Secure app configurations using Azure Key Vault**

---

2. Tools Used

- **Azure DevOps Pipelines** – Automates deployment
- **Azure App Service** – Hosts the web application
- **Azure Traffic Manager** – Routes traffic between Blue and Green environments
- **Azure App Service Deployment Slots** – Enables swapping environments
- **Azure Key Vault** – Stores application secrets
- **PowerShell & YAML** – Automates infrastructure provisioning

---

3. Analysis Approach

Challenges Without Blue-Green Deployment

❌ **Deployment downtime** when updating applications
❌ **Difficult rollback** process if a deployment fails
❌ **Inconsistent testing environments**
❌ **Customer impact during production updates**

Proposed Solution

✅ **Deploy new versions in the Green slot** without affecting users
✅ **Run tests and validations on the Green slot** before switching traffic
✅ **Instant rollback by switching back to the Blue slot** if issues arise
✅ **Use Azure Traffic Manager** to manage **gradual rollout strategies**

4. Step-by-Step Implementation

Step 1: Create an Azure Web App with Deployment Slots

1. **Provision an Azure Web App:**

Unset
```
az group create --name BlueGreenRG --location eastus

az appservice plan create --name BlueGreenPlan --resource-group
BlueGreenRG --sku S1 --is-linux

az webapp create --resource-group BlueGreenRG --plan BlueGreenPlan
--name blue-webapp --runtime "DOTNETCORE:6.0"
```

2. **Create a Deployment Slot (Green):**

Unset
```
az webapp deployment slot create --name blue-webapp --resource-group
BlueGreenRG --slot green
```

Step 2: Store Configuration in Azure Key Vault

1. **Create an Azure Key Vault:**

Unset
```
az keyvault create --name BlueGreenKeyVault --resource-group
BlueGreenRG --location eastus
```

2. **Store an API key in Key Vault:**

Unset
```
az keyvault secret set --vault-name BlueGreenKeyVault --name "APIKey"
--value "SecureAPIKey123"
```

Step 3: Set Up Azure DevOps Repository and CI Pipeline

1. **Clone the Azure Repos Git Repository:**

```
Unset
git clone https://dev.azure.com/MyOrg/BlueGreenDeployment.git

cd BlueGreenDeployment
```

2. **Create a simple .NET Web Application (`Program.cs`):**

```
Unset
var builder = WebApplication.CreateBuilder(args);

var app = builder.Build();

app.MapGet("/", () => "Hello from Blue-Green Deployment!");

app.Run();
```

3. **Modify the CI pipeline (`ci-pipeline.yml`):**

```
Unset
trigger:

  branches:

    include:

      - main



pool:

  vmImage: 'ubuntu-latest'



steps:

- task: UseDotNet@2
```

```
  inputs:
    packageType: 'sdk'
    version: '6.x'

- script: dotnet restore
  displayName: 'Restore dependencies'

- script: dotnet build --configuration Release
  displayName: 'Build Web App'

- task: ArchiveFiles@2
  inputs:
    rootFolderOrFile: '$(Build.SourcesDirectory)'
    includeRootFolder: false
    archiveType: 'zip'
    archiveFile: '$(Build.ArtifactStagingDirectory)/webapp.zip'

- task: PublishBuildArtifacts@1
  inputs:
    pathToPublish: '$(Build.ArtifactStagingDirectory)/webapp.zip'
    artifactName: 'drop'
```

Step 4: Set Up CD Pipeline for Blue-Green Deployment

1. **Modify the CD pipeline (`cd-pipeline.yml`):**

Unset
```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

stages:
- stage: DeployToGreen
  jobs:
  - job: Deploy
    steps:
    - task: DownloadBuildArtifacts@0
      inputs:
        artifactName: 'drop'
        downloadPath: '$(System.DefaultWorkingDirectory)'

    - task: AzureWebApp@1
      inputs:
        azureSubscription: 'MyAzureSubscription'
        appType: 'webApp'
```

```
        appName: 'blue-webapp'
        slotName: 'green'
        package: '$(System.DefaultWorkingDirectory)/drop/webapp.zip'

- stage: TestGreenSlot
  jobs:
  - job: Validate
    steps:
    - script: curl -f https://blue-webapp-green.azurewebsites.net ||
exit 1
      displayName: 'Health Check for Green Slot'

- stage: SwapSlots
  dependsOn: TestGreenSlot
  jobs:
  - job: Swap
    steps:
    - task: AzureCLI@2
      inputs:
        azureSubscription: 'MyAzureSubscription'
        scriptType: 'bash'
        scriptLocation: 'inlineScript'
        inlineScript: |
```

```
         az webapp deployment slot swap --name blue-webapp
--resource-group BlueGreenRG --slot green
```

Step 5: Implement Rollback Strategy

1. **Rollback to previous version in case of failure:**

```
Unset
az webapp deployment slot swap --name blue-webapp --resource-group
BlueGreenRG --slot green
```

2. **Configure automatic rollback in Azure DevOps:**
   - Navigate to **Pipelines** → **Releases** → **Pre-deployment Conditions**
   - Enable **Rollback on failure**

Step 6: Gradual Traffic Switching Using Azure Traffic Manager

1. **Create an Azure Traffic Manager Profile:**

```
Unset
az network traffic-manager profile create --name BlueGreenTM
--resource-group BlueGreenRG --routing-method Weighted --dns-name
bluegreentm
```

2. **Add endpoints for Blue and Green Slots:**

```
Unset
az network traffic-manager endpoint create --resource-group BlueGreenRG
--profile-name BlueGreenTM --name blue-endpoint --type azureEndpoints
--target-resource-id
/subscriptions/<sub_id>/resourceGroups/BlueGreenRG/providers/Microsoft.
Web/sites/blue-webapp --weight 100
```

```
az network traffic-manager endpoint create --resource-group BlueGreenRG
--profile-name BlueGreenTM --name green-endpoint --type azureEndpoints
--target-resource-id
/subscriptions/<sub_id>/resourceGroups/BlueGreenRG/providers/Microsoft.
Web/sites/blue-webapp/slots/green --weight 0
```

3. **Gradually switch traffic to Green:**

```
Unset
az network traffic-manager endpoint update --resource-group BlueGreenRG
--profile-name BlueGreenTM --name green-endpoint --weight 50
```

---

5. Conclusion

🚀 **Key Benefits of Blue-Green Deployment in Azure DevOps:**
✅ **Ensures zero-downtime deployment** with deployment slots
✅ **Enables instant rollback** if the new version has issues
✅ **Minimizes risk** by testing before going live
✅ **Allows gradual rollout** using Traffic Manager

---

6. Real-Time Example

An **e-commerce company** launching new website features can use **Blue-Green Deployment** to **test updates safely** and **switch traffic seamlessly without downtime**.

Project 8: Implementing Azure DevOps CI/CD Pipeline for Containerized Applications with Azure Kubernetes Service (AKS) and Helm

---

1. Project Scope

This project focuses on **automating the deployment of containerized applications** using **Azure DevOps Pipelines**, **Azure Kubernetes Service (AKS)**, and **Helm**. The goal is to ensure **scalability, high availability, and automated updates** for containerized workloads.

Key Features:

✅ **Automate CI/CD for Kubernetes deployments**
✅ **Use Helm for managing Kubernetes manifests**
✅ **Secure Kubernetes secrets using Azure Key Vault**
✅ **Enable rolling updates for zero downtime**
✅ **Monitor workloads using Prometheus & Grafana**

---

2. Tools Used

- **Azure DevOps Pipelines** – Automates build and deployment
- **Azure Kubernetes Service (AKS)** – Hosts containerized workloads
- **Docker & Azure Container Registry (ACR)** – Stores container images
- **Helm** – Manages Kubernetes deployments
- **Azure Key Vault** – Secures Kubernetes secrets
- **Prometheus & Grafana** – Monitors AKS workloads

---

3. Analysis Approach

Challenges Without Automated Kubernetes Deployments

❌ **Manual deployments** lead to inconsistencies
❌ **Lack of version control** for Kubernetes configurations
❌ **Security risks** due to exposed secrets in YAML files
❌ **Difficult rollback strategy** if an issue arises

Proposed Solution

✅ **Use Azure DevOps CI/CD Pipelines** to automate deployments
✅ **Leverage Helm for versioned Kubernetes deployments**
✅ **Secure Kubernetes secrets using Azure Key Vault**
✅ **Enable auto-scaling for high availability**

4. Step-by-Step Implementation

Step 1: Create an AKS Cluster and Configure Kubernetes Context

1. **Provision an Azure Kubernetes Service (AKS) Cluster:**

```
Unset
az group create --name AKSRG --location eastus

az aks create --resource-group AKSRG --name MyAKSCluster --node-count 3
--generate-ssh-keys
```

2. **Connect to the AKS Cluster:**

```
Unset
az aks get-credentials --resource-group AKSRG --name MyAKSCluster

kubectl get nodes
```

Step 2: Store Kubernetes Secrets in Azure Key Vault

1. **Create an Azure Key Vault:**

```
Unset
az keyvault create --name AKSKeyVault --resource-group AKSRG --location
eastus
```

2. **Store a database connection string:**

```
Unset
az keyvault secret set --vault-name AKSKeyVault --name
"DBConnectionString" --value "Server=mydbserver;Database=mydb;"
```

Step 3: Develop and Push a Sample Containerized Application

1. **Clone the Azure DevOps Repository:**

```
git clone https://dev.azure.com/MyOrg/KubernetesApp.git

cd KubernetesApp
```

2. **Create a Dockerfile (`Dockerfile`):**

```
FROM node:14

WORKDIR /app

COPY package.json .

RUN npm install

COPY . .

CMD ["node", "server.js"]

EXPOSE 3000
```

3. **Commit and push the code:**

```
git add .

git commit -m "Added Dockerfile"

git push origin main
```

Step 4: Create an Azure DevOps CI Pipeline for Building and Pushing Docker Images

1. **Modify the CI pipeline (`ci-pipeline.yml`):**

Unset

```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

steps:
- task: Docker@2
  inputs:
    command: 'buildAndPush'
    repository: 'myacr.azurecr.io/kubernetesapp'
    dockerfile: 'Dockerfile'
    containerRegistry: 'MyAzureContainerRegistry'
    tags: '$(Build.BuildId)'

- task: PublishBuildArtifacts@1
  inputs:
    pathToPublish: '$(Build.ArtifactStagingDirectory)'
    artifactName: 'drop'
```

Step 5: Configure Helm for Kubernetes Deployment

1. **Create a Helm Chart (`helm/kubernetesapp/Chart.yaml`):**

```
Unset
apiVersion: v2

name: kubernetesapp

description: A Helm chart for deploying a Node.js application

version: 1.0.0

appVersion: "1.0"
```

2. **Define Kubernetes Deployment and Service (`helm/kubernetesapp/templates/deployment.yaml`):**

```
Unset
apiVersion: apps/v1

kind: Deployment

metadata:

  name: kubernetesapp

spec:

  replicas: 2

  selector:

    matchLabels:

      app: kubernetesapp

  template:

    metadata:

      labels:

        app: kubernetesapp

    spec:
```

```
      containers:
      - name: kubernetesapp
        image: myacr.azurecr.io/kubernetesapp:latest
        ports:
        - containerPort: 3000
```

3. **Define a Service for Load Balancing (`helm/kubernetesapp/templates/service.yaml`):**

```
Unset
apiVersion: v1
kind: Service
metadata:
  name: kubernetesapp
spec:
  type: LoadBalancer
  selector:
    app: kubernetesapp
  ports:
    - protocol: TCP
      port: 80
      targetPort: 3000
```

Step 6: Create an Azure DevOps CD Pipeline for AKS Deployment Using Helm

1. **Modify the CD pipeline (`cd-pipeline.yml`):**

Unset
```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

stages:
- stage: DeployToAKS
  jobs:
  - job: Deploy
    steps:
    - task: HelmDeploy@0
      inputs:
        connectionType: 'Azure Resource Manager'
        azureSubscription: 'MyAzureSubscription'
        azureResourceGroup: 'AKSRG'
        kubernetesCluster: 'MyAKSCluster'
        namespace: 'default'
        command: 'upgrade'
        chartType: 'FilePath'
        chartPath: 'helm/kubernetesapp'
```

```
      releaseName: 'kubernetesapp'
```

Step 7: Enable Auto-Scaling for AKS Deployment

1. **Enable Horizontal Pod Autoscaler (HPA):**

Unset
```
kubectl autoscale deployment kubernetesapp --cpu-percent=50 --min=2
--max=5
```

2. **Monitor autoscaling events:**

Unset
```
kubectl get hpa
```

Step 8: Enable Monitoring Using Prometheus and Grafana

1. **Deploy Prometheus in AKS:**

Unset
```
helm repo add prometheus-community
https://prometheus-community.github.io/helm-charts

helm install prometheus prometheus-community/kube-prometheus-stack
```

2. **Deploy Grafana for Visualization:**

Unset
```
helm install grafana stable/grafana

kubectl port-forward svc/grafana 3000:80
```

3. **Access Grafana dashboard at** `http://localhost:3000/`

5. Conclusion

🚀 **Key Benefits of CI/CD for AKS with Helm:**
✅ **Automates Kubernetes deployments with Azure DevOps**
✅ **Ensures high availability using auto-scaling**
✅ **Secures sensitive configurations using Azure Key Vault**
✅ **Enables monitoring with Prometheus and Grafana**

6. Real-Time Example

A **fintech company** deploying microservices-based banking applications can use **Azure DevOps, AKS, and Helm** to **ensure high availability, automated scaling, and security** for its workloads.

Project 9: Implementing Azure DevOps Pipeline for Infrastructure as Code (IaC) Using Terraform on Azure

---

1. Project Scope

This project focuses on **using Terraform** to define, provision, and manage **Azure infrastructure** through **Azure DevOps Pipelines.** Terraform enables Infrastructure as Code (IaC), making it easy to automate cloud resource provisioning while ensuring consistency and scalability.

Key Features:

✅ **Automate Infrastructure Deployment using Terraform**
✅ **Manage Infrastructure as Code (IaC) in Azure DevOps**
✅ **Use Remote State for Team Collaboration**
✅ **Ensure Consistent Deployments Across Environments (Dev, QA, Prod)**
✅ **Implement Role-Based Access Control (RBAC) Policies**

---

2. Tools Used

- **Azure DevOps Pipelines** – Automates Terraform execution
- **Terraform** – Manages Azure Infrastructure as Code
- **Azure Storage Account** – Stores Terraform state files
- **Azure Key Vault** – Secures Terraform secrets
- **PowerShell & YAML** – Used for automation scripting

---

3. Analysis Approach

Challenges Without Infrastructure as Code (IaC)

❌ **Manual provisioning** is error-prone and time-consuming
❌ **Difficult to track changes** and maintain consistency
❌ **Security risks** due to hardcoded secrets
❌ **No version control** for infrastructure configurations

Proposed Solution

✅ Use **Terraform for Infrastructure as Code (IaC)**
✅ Automate **Azure resource provisioning** with **Azure DevOps Pipelines**
✅ Store **Terraform state remotely** using **Azure Storage Account**
✅ Secure credentials using **Azure Key Vault**

---

4. Step-by-Step Implementation

Step 1: Set Up an Azure Storage Account for Terraform State

1. **Create a Resource Group:**

Unset
```
az group create --name TerraformRG --location eastus
```

2. **Create an Azure Storage Account:**

Unset
```
az storage account create --name terraformstate1234 --resource-group
TerraformRG --location eastus --sku Standard_LRS
```

3. **Create a Storage Container for Terraform State:**

Unset
```
az storage container create --name tfstate --account-name
terraformstate1234
```

Step 2: Store Terraform Secrets in Azure Key Vault

1. **Create an Azure Key Vault:**

Unset
```
az keyvault create --name TerraformKeyVault --resource-group
TerraformRG --location eastus
```

2. **Store Service Principal Credentials in Key Vault:**

Unset
```
az keyvault secret set --vault-name TerraformKeyVault --name "ClientID"
--value "your-client-id"
```

```
az keyvault secret set --vault-name TerraformKeyVault --name
"ClientSecret" --value "your-client-secret"
```

Step 3: Create a Terraform Configuration File (`main.tf`)

1. **Clone the Azure DevOps Repository:**

```
git clone https://dev.azure.com/MyOrg/TerraformDeployment.git

cd TerraformDeployment
```

2. **Define Azure Infrastructure in `main.tf`:**

```
terraform {

  backend "azurerm" {

    resource_group_name  = "TerraformRG"

    storage_account_name = "terraformstate1234"

    container_name       = "tfstate"

    key                  = "terraform.tfstate"

  }

}


provider "azurerm" {

  features {}

}
```

```
resource "azurerm_resource_group" "example" {
  name     = "MyTerraformRG"
  location = "East US"
}
```

3. **Commit and Push Code:**

```
Unset
git add .
git commit -m "Added Terraform configuration"
git push origin main
```

Step 4: Configure Azure DevOps CI Pipeline for Terraform Plan

1. **Modify the CI Pipeline (`terraform-ci.yml`):**

```
Unset
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'
```

```yaml
steps:
- task: TerraformInstaller@1
  inputs:
    terraformVersion: 'latest'

- task: TerraformTaskV2@2
  displayName: 'Initialize Terraform'
  inputs:
    provider: 'azurerm'
    command: 'init'
    backendServiceArm: 'MyAzureSubscription'
    backendAzureRmResourceGroupName: 'TerraformRG'
    backendAzureRmStorageAccountName: 'terraformstate1234'
    backendAzureRmContainerName: 'tfstate'
    backendAzureRmKey: 'terraform.tfstate'

- task: TerraformTaskV2@2
  displayName: 'Run Terraform Plan'
  inputs:
    provider: 'azurerm'
    command: 'plan'
    environmentServiceNameAzureRM: 'MyAzureSubscription'
```

Step 5: Configure Azure DevOps CD Pipeline for Terraform Apply

1. **Modify the CD Pipeline (`terraform-cd.yml`):**

```
trigger:
  branches:
    include:
      - main

pool:
  vmImage: 'ubuntu-latest'

stages:
- stage: Deploy
  jobs:
  - job: ApplyTerraform
    steps:
    - task: TerraformTaskV2@2
      displayName: 'Apply Terraform Configuration'
      inputs:
        provider: 'azurerm'
        command: 'apply'
        environmentServiceNameAzureRM: 'MyAzureSubscription'
        commandOptions: '-auto-approve'
```

Step 6: Implement Role-Based Access Control (RBAC) Policies

1. **Assign Contributor Role to Terraform Service Principal:**

```
Unset
az role assignment create --assignee "<service-principal-id>" --role
Contributor --scope
"/subscriptions/<subscription-id>/resourceGroups/TerraformRG"
```

Step 7: Enable Automated Rollback for Terraform Deployments

1. **Track Terraform Deployment History:**

```
Unset
terraform show
```

2. **Rollback to Previous State if Deployment Fails:**

```
Unset
terraform apply -refresh=false terraform.tfstate.backup
```

---

5. Conclusion

🚀 **Key Benefits of Terraform for Azure Infrastructure:**

✅ Automates Infrastructure Deployment using Terraform & Azure DevOps
✅ Ensures Consistency with Remote State Storage
✅ Enhances Security by Storing Secrets in Azure Key Vault
✅ Enables Rollback to Previous Deployments

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6. Real-Time Example

A **large enterprise** managing multiple cloud environments (Dev, QA, Prod) can use **Terraform in Azure DevOps Pipelines** to automate **infrastructure provisioning** while ensuring **consistency and security** across teams.

Project 10: Implementing Azure DevOps CI/CD Pipeline for Azure API Management (APIM) with Automated API Deployment

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1. Project Scope

This project focuses on **automating API deployment and management** using **Azure DevOps Pipelines** and **Azure API Management (APIM)**. The goal is to ensure seamless API versioning, security enforcement, and automated updates across different environments.

Key Features:

✅ **Automate API deployment and versioning using Azure DevOps**
✅ **Enforce security policies (Rate Limiting, JWT, OAuth, API Keys)**
✅ **Use Azure API Management (APIM) for API gateway capabilities**
✅ **Enable logging and monitoring for API traffic**
✅ **Integrate automated API testing in CI/CD pipeline**

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2. Tools Used

- **Azure DevOps Pipelines** – Automates API deployment
- **Azure API Management (APIM)** – API gateway for managing APIs
- **Swagger / OpenAPI** – Defines API specifications
- **Azure Key Vault** – Stores API secrets and keys
- **Azure Monitor & App Insights** – API logging and monitoring
- **PowerShell & YAML** – Automation scripting

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3. Analysis Approach

Challenges Without API Management & Automation

❌ **Difficult to manage multiple API versions**
❌ **No centralized security enforcement (Rate Limits, Authentication, IP Restrictions)**
❌ **Manual API deployments cause inconsistencies**
❌ **Lack of monitoring and logging for API performance**

Proposed Solution

✅ Automate **API deployment, versioning, and security enforcement** using **Azure DevOps & APIM**
✅ **Centralize API authentication** using **OAuth, JWT, and API Keys**
✅ **Ensure API high availability and load balancing**
✅ **Enable monitoring & logging with Azure Monitor and App Insights**

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4. Step-by-Step Implementation

Step 1: Provision an Azure API Management Instance

1. **Create a Resource Group:**

```
Unset
az group create --name APIMRG --location eastus
```

2. **Create an API Management Instance:**

```
Unset
az apim create --name MyAPIM --resource-group APIMRG --publisher-name
"MyCompany" --publisher-email "admin@mycompany.com" --sku-name
Consumption
```

Step 2: Define API Specifications Using OpenAPI (Swagger)

1. **Create an OpenAPI Specification File (`swagger.json`):**

```
Unset
{
  "swagger": "2.0",
  "info": {
    "title": "My API",
    "description": "API for managing users",
    "version": "1.0.0"
  },
  "paths": {
    "/users": {
      "get": {
```

```
          "summary": "Get all users",
          "responses": {
            "200": {
              "description": "OK"
            }
          }
        }
      }
    }
  }
```

2. **Commit and Push the API Spec to Azure Repos:**

```
Unset
git add .
git commit -m "Added OpenAPI specification"
git push origin main
```

Step 3: Configure Azure DevOps CI Pipeline for API Validation

1. **Modify the CI pipeline (`api-ci.yml`):**

```
Unset
trigger:
  branches:
    include:
```

```
    - main

pool:
  vmImage: 'ubuntu-latest'

steps:
- task: OpenApi@1
  inputs:
    openApiFile: 'swagger.json'
    validationRules: 'All'

- task: PublishBuildArtifacts@1
  inputs:
    pathToPublish: 'swagger.json'
    artifactName: 'drop'
```

Step 4: Configure Azure DevOps CD Pipeline for API Deployment to APIM

1. **Modify the CD pipeline (`api-cd.yml`):**

Unset
```
trigger:
  branches:
    include:
```

```
      - main


pool:
  vmImage: 'ubuntu-latest'


stages:
- stage: DeployToAPIM
  jobs:
  - job: Deploy
    steps:
    - task: DownloadBuildArtifacts@0
      inputs:
        artifactName: 'drop'
        downloadPath: '$(System.DefaultWorkingDirectory)'


    - task: AzureCLI@2
      inputs:
        azureSubscription: 'MyAzureSubscription'
        scriptType: 'bash'
        scriptLocation: 'inlineScript'
        inlineScript: |
          az apim api import --resource-group APIMRG --service-name
MyAPIM --path /users --api-id MyAPI --specification-format OpenAPI
```

```
--specification-path
$(System.DefaultWorkingDirectory)/drop/swagger.json
```

Step 5: Implement API Security Policies

1. **Apply JWT Authentication Policy in APIM (`jwt-policy.xml`):**

```
Unset
<inbound>

  <validate-jwt header-name="Authorization"
failed-validation-httpcode="401">

    <openid-config
url="https://login.microsoftonline.com/{tenant-id}/v2.0/.well-known/ope
nid-configuration" />

    <audiences>

      <audience>api://my-api</audience>

    </audiences>

  </validate-jwt>

</inbound>
```

2. **Apply Rate Limiting Policy in APIM (`rate-limit-policy.xml`):**

```
Unset
<inbound>

  <rate-limit calls="10" renewal-period="60" />

</inbound>
```

3. **Apply these policies via Azure CLI:**

Unset
```
az apim api policy create --resource-group APIMRG --service-name MyAPIM
--api-id MyAPI --xml-policy-file jwt-policy.xml
```

Step 6: Enable API Logging & Monitoring with Azure Monitor

1. **Enable App Insights for API Management:**

Unset
```
az monitor app-insights component create --app MyAPIMInsights
--location eastus --resource-group APIMRG
```

2. **Enable Request Logging in APIM:**

Unset
```
<inbound>

  <base />

  <log-to-eventhub logger-id="apim-logger">

    <message>Request received</message>

  </log-to-eventhub>

</inbound>
```

3. **Deploy the Logging Policy in APIM:**

Unset
```
az apim api policy create --resource-group APIMRG --service-name MyAPIM
--api-id MyAPI --xml-policy-file logging-policy.xml
```

Step 7: Automate API Testing Using Postman & Newman

1. **Run API Tests in Azure DevOps CI/CD Pipeline:**

Unset
```
- task: NodeTool@0

  inputs:

    versionSpec: '16.x'


- script: |

    npm install -g newman

    newman run api-tests.postman_collection.json --reporters cli,junit

  displayName: 'Run API Tests with Newman'
```

---

5. Conclusion

🚀 Key Benefits of Azure API Management with DevOps:
✅ Automates API deployments and updates
✅ Enforces security policies (OAuth, JWT, API Keys, Rate Limiting)
✅ Enables centralized logging and monitoring for APIs
✅ Integrates automated API testing into DevOps workflows

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6. Real-Time Example

A **banking company** can use **Azure API Management (APIM) and Azure DevOps Pipelines** to **securely expose APIs**, enforce **rate limits**, and enable **seamless API versioning** while ensuring **compliance with security policies**.

🎉 Congratulations! All 10 Azure DevOps Real-Time Projects Are Completed! 🎉

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