Getting Started With GitHub Actions

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Pipelines are an integral part of automated software testing and deployment, but prior to 2019, third-party tools were needed to create them for GitHub repositories. With the inception of GitHub Actions, we can now create sophisticated pipelines using text-based configurations that are stored directly within our GitHub repository.

In this Refcard, we will explore the fundamentals of Continuous Integration and Continuous Delivery (CI/CD), delve into the basics of GitHub Action workflows, and examine how we can automatically deploy our application using Azure. While these concepts appear simple on the surface, they are crucial in order to understand how to create powerful workflows that meet our needs on complex and large-scale projects.

CI/CD OVERVIEW

The value of our software is not only found in the code we write, but also in how we package and deliver that code. Beyond the code we write, we must also do the following to meet the needs of our customers and drive revenue:

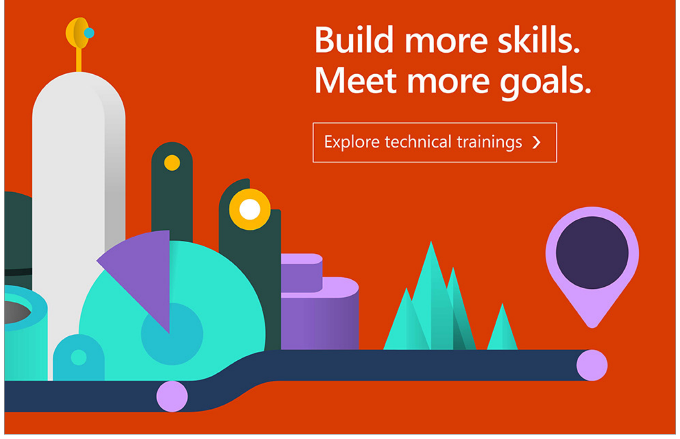
- Create executables
- Test that the executables meet their specifications
- Deliver the executables

Since the inception of software development, this has typically been a manual process in which engineers create executables, the Quality Assurance (QA) team manually runs through a suite of tests and signs off on them, and operations staff manually deploy the certified executables into a production environment. In the last two decades though, operations and release engineering has progressed to the point where nearly all steps in the delivery process can be automated.

The series of steps that brings software from code to its execution in production is inherently driven by **business needs**. For example, some applications may require that acceptance and performance tests be run before the application can be deployed, while other applications may only require unit and integration tests.

Likewise, some applications may be deployed to a single production environment, while others may package up an executable that can be downloaded by countless customers. Although the specific steps will vary by our business needs, the general principle remains the same: executing steps in series and in parallel.

When executed manually, this is an arduous, costly process and becomes increasingly burdensome as more steps are added.



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[*] Nigel Frank Microsoft Azure Salary Survey (June 2020)
https://www.nigelfrank.com/microsoft-azure-salary-survey/

CONTINUOUS INTEGRATION

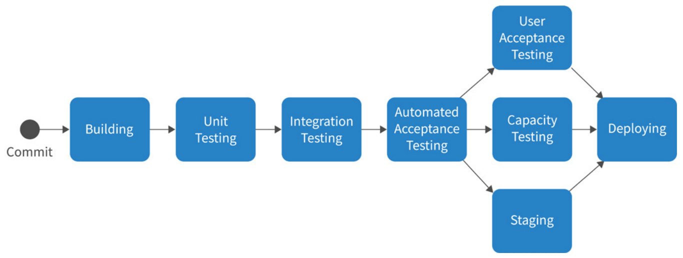
The first step in the march toward automation was **Continuous Integration** (CI). Prior to CI, developers would work on separate pieces of an application and test them in isolation. Once enough code was ready, the development team would combine their parts and test them together in a process that came to be known as **Big Bang Integration**. In most cases, integration never worked as expected and would take days or weeks to resolve any problems that occurred. This costly process would repeat every few weeks until all the desired features were ready, and when done at the last minute, it could prove disastrous.

To improve this process, developers started automating their unit and integration tests, running them at least once a day or, if possible, after each check-in to the repository. This approach ensured that integration was done dozens or even hundreds of times a day and that tiny segments of the application — rather than large, monolithic chunks — were integrated.

This CI process drastically improved both turnaround time and application quality, setting the groundwork for the next logical step in the automation process: **Continuous Delivery** (CD).

CONTINUOUS DELIVERY

While CI focuses on the integration of code, CD automates the entire delivery process, from check-in to deployment. The core concept of CD is a **pipeline**, which represents a set of ordered **stages** — some are executed in series and others are executed in parallel. An example pipeline is illustrated below:



In this case, the CD pipeline starts with a commit to the repository, which then initiates a build. Once the build is complete and an executable is created, the executable is unit tested. If all unit tests pass, the executable is integration tested; if all integration tests pass, the acceptance tests are run.

And once all acceptance tests pass, the pipeline runs three stages in parallel within a production environment:

1. **User Acceptance Testing** (UAT) – a set of manual tests, such as UI tests or other acceptance tests, that require human judgment to determine if they pass. Since completion of this stage requires manual sign-off, the progression of the pipeline is said to be *gated* until this stage is complete.
2. **Capacity Testing** – performance tests that exercise if the application meets its timing and capacity specifications in a production environment.
3. **Staging** – the executables and its accompanying configuration are staged and prepared for deployment.

If all three of these stages pass — in the case of the manual UATs, when a tester signs off that the tests have passed — the staged executables and configuration are deployed to the production environment (or moved to a public-facing server so that customers can download the application). While some stages can be completed manually by pressing a button in the pipeline, it is best to automate as many, if not all, stages as possible. A fully automated pipeline allows developers to check in code to a repository and, if all tests pass, ensure that their changes are pushed to production in a consistent and repeatable manner without any human interaction.

The concepts of CI/CD are crucial to the advancement of software development, and their business and practical benefits are reaped when we integrate them into our repositories. While there are countless repositories to choose from, one has become the most popular option by far: GitHub.

GITHUB ACTIONS KEY CONCEPTS

GitHub hosts more than 200 million repositories, and for 11 years since its inception, developers were only able to create CI/CD pipelines using third-party tools, such as Travis CI and CircleCI. This external process changed in November of 2019, when GitHub announced the launch of GitHub Actions. GitHub Actions is a CI/CD tool that is incorporated directly into every GitHub repository, utilizing text-based configuration files that reside directly within the repository.

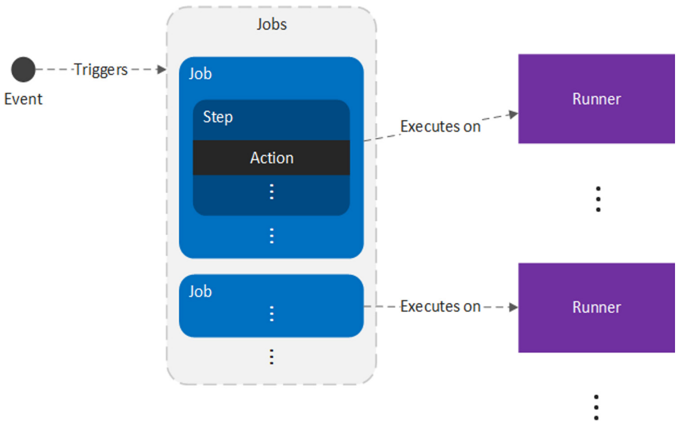
The root concept in GitHub Actions is a **workflow**, or a series of automated procedures. In practice, a workflow is similar to a pipeline and allows developers to configure a series of stages that can be executed each time a specific event is triggered. Every repository can have any number of workflows, and each workflow is composed of the following components:

COMPONENT	DESCRIPTION
Job	*A set of steps that are executed on the same runner* By default, if a workflow has more than one job, the jobs are executed in parallel, but jobs can be configured to run in series by declaring that one job depends on another. If job B depends on job A, job B will only execute if job A completes successfully.
Step	*A task that is composed of one or more shell commands or actions* All steps from a job are executed on the same runner, and therefore, can share data with one another.

TABLE CONTINUES ON NEXT PAGE

Action	*A prepackaged set of procedures that can be executed within a step* There are numerous actions already available through the GitHub community that perform common tasks, such as checking out code or uploading artifacts.
Event	*A stimulus that triggers the execution of a workflow* One of the most common events is a user checking in code to a repository.
Runner	*A server that executes jobs on a specific Operating System (OS) or platform* Runners can either be hosted by GitHub or on standalone servers.

The relationship between these components is illustrated below:



In practice, workflows are more generalized than a CD pipeline, but they are closely related:

- Workflows = pipelines
- Jobs = stages
- Steps = the series of procedures that make up a stage

EXAMPLE WORKFLOW

To demonstrate a workflow, we can create a small project with several tests. For this example, we will use the `dzone-github-actions-refcard-example` project. This project runs a Representational State Transfer (REST) Application Programming Interface (API) application that responds with a "Hello, world!" message from the `/hello` endpoint and has a single test to ensure that the response body of the endpoint is correct.

To clone the repository, execute the following commands:

```
git clone git@github.com:albanoj2/dzone-github-
actions-refcard-example.git
git checkout code
```

Once the project is ready, we can build a new workflow by creating a `.yml` file in the `.github/workflows/` directory of our GitHub repository — for instance, `.github/workflows/example.yml`. We can then configure our workflow to check out our repository and run our tests using the `mvn test` command by adding the following to our `example.yml` file:

```
name: dzone-github-actions-example

on: [push]

jobs:
  build:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v2
      - run: mvn package -DskipTests
      - name: Upload Artifacts
        uses: actions/upload-artifact@v2
        with:
          name: jar-file
          path: target/github-actions-example-
1.0.0.jar

  unit-test:
    needs: build
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v2
      - run: mvn test
```

This configuration is broken up into three main parts:

1. **name** – an optional name of the workflow.
2. **on** – the trigger that executes the workflow — in this case, when a commit is pushed to the repository, denoted by `push`. The full syntax for the **on** field is documented in the Workflow syntax for GitHub Actions page.
3. `jobs` – the jobs that make up the workflow.

The jobs field contains two jobs:

1. `build` – the job used to to build our project. Note that the name `build` does not have any special significance and any name can be used. The `runs-on` field signifies the OS and environment that the job will execute on, such as the latest version of Ubuntu (denoted by `ubuntu-latest`).

   The `steps` field denotes the steps of the job. In this case, there are three steps:

   – **Checking out the repository** – checks out the code in the repository using the Checkout action. Since we do not know the state of the runner that will execute each job, we first have to check out our repository before we can access our code. We can select any of the available actions to run with the `uses` field.

See the Workflow Syntax page for more information.

- **Building the repository** – we execute a shell command — in this case, `mvn package -DskipTests` — using the `run` field. This command packages our application into a Jar file without running the tests (which will be executed in a subsequent job).

  If needed, we can also run multiple shell commands using the pipe character. For example, we can echo `Running a build` and then execute the build as follows

```
- run: |
    echo "Running a build"
    mvn package -DskipTests
```

- **Uploading artifacts** – as we will see later, we will need access to the JAR file (our executable) created in this job. To store it for later, we upload the JAR artifact using the `upload-artifact` action, assigning the name of the uploaded artifact (so we can reference it later) using the `name` field and specifying the path of the artifact using the `path` field.

  For more information, you can visit the upload artifacts documentation.

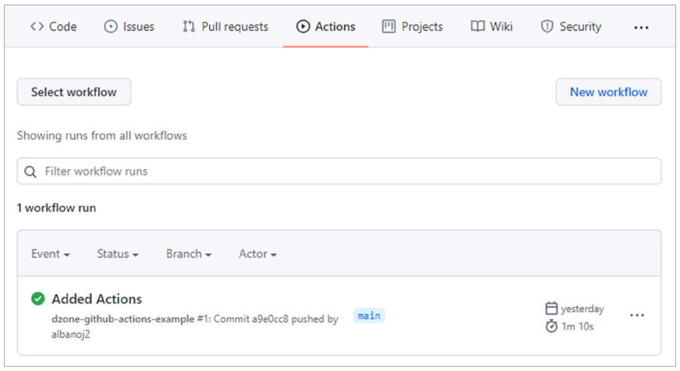
2. `unit-test` – the job used to run our unit tests. This job is similar to our `build` job, but instead of running the `mvn package -DskipTests` command, we run the `mvn test` command.

   In addition, we also add the `needs` field, whose value is simply the name of the job that our `unit-test` depends on. In our case, we specify that our `unit-test` job depends on our `build` job using `needs: build`.

   With this relationship configured, our `unit-test` job will only execute once the `build` job successfully completes. See the Workflow Syntax page for more information.

When we commit this `example.yml` file, GitHub recognizes that a workflow has been configured and executes our workflow. If we click the **Actions** tab in our GitHub repository, we can see all workflow runs that correspond to our commits.

SEE SCREENSHOT IN NEXT COLUMN

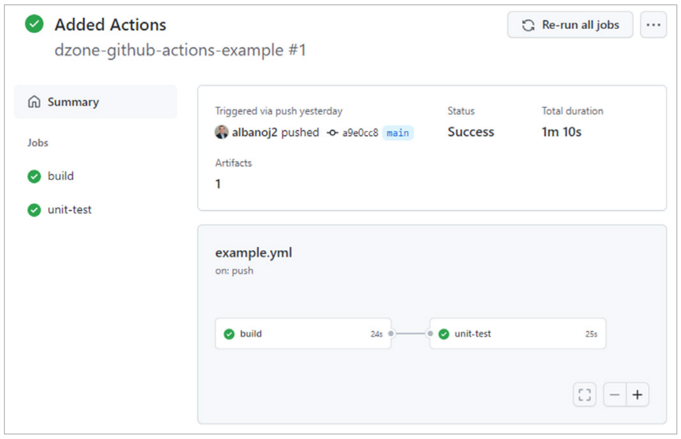


Showing runs from all workflows

1 workflow run

Added Actions
dzone-github-actions-example #1: Commit a9e0cc8 pushed by albanoj2 main
yesterday
1m 10s

If we click on a workflow run — here, `Added Actions` — we can see the status of our pipeline for that run along with status and duration information:

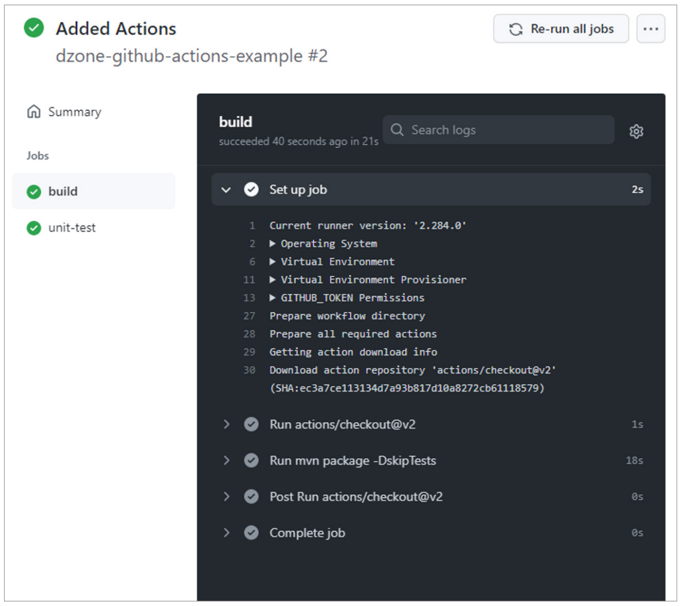


Added Actions
dzone-github-actions-example #1

Triggered via push yesterday: albanoj2 pushed a9e0cc8 main
Status: Success
Total duration: 1m 10s
Artifacts: 1

example.yml
on: push

Lastly, if we click on the `build` job, we see the log output that corresponds to the execution of our `build` job in our `Added Actions` commit:



Added Actions
dzone-github-actions-example #2

build
succeeded 40 seconds ago in 21s

Set up job 2s

```
Current runner version: '2.284.0'
▶ Operating System
▶ Virtual Environment
▶ Virtual Environment Provisioner
▶ GITHUB_TOKEN Permissions
Prepare workflow directory
Prepare all required actions
Getting action download info
Download action repository 'actions/checkout@v2'
(SHA:ec3a7ce113134d7a93b817d10a8272cb61118579)
```

Run actions/checkout@v2 1s
Run mvn package -DskipTests 18s
Post Run actions/checkout@v2 0s
Complete job 0s

Although syntax for a GitHub Actions workflow is simple, it provides the mechanisms necessary to create sophisticated pipelines and execute nearly any procedures that we need to satisfy our business objectives.

DEPLOYING WITH GITHUB ACTIONS

Editor's Note: This section demonstrates how to use GitHub Actions for deployment to Azure — users subscribed to Azure services (paid) are able to follow along with their existing account.

With our application built and tested, we can now deploy it. There are numerous cloud providers to choose from — each with their advantages and disadvantages — and for this section, we will use Azure. To deploy to Azure, we must create a `Dockerfile` at the root of our project with the following contents:

```
FROM openjdk:11

COPY target/*.jar app.jar

EXPOSE 8080

ENTRYPOINT ["java", "-jar", "/app.jar"]
```

To set up our Azure environment, we must complete these steps:

1. Navigate to your Azure services portal.
2. Create a new subscription. We will reference the ID of this new subscription as `<subscription_id>`.
3. Create a new container registry. We will reference the container registry URL as `<login_server>`. In this case, we will use `albanoj2.azurecr.io`.
4. Create a new App Service:
   - Set *Name* to a unique name (must be unique across Azure). In this case, we will use `dzone-github-actions-example`.
   - Set *Publish* to *Docker Container*.
   - Set *Operating System* to *Linux*.
5. Install the Azure CLI locally:

```
curl -sL https://aka.ms/InstallAzureCLIDeb \
  | sudo bash
```

6. Log in using the Azure CLI:

```
az login
```

7. Create a new service principal:

```
az ad sp create-for-rbac \
  --role contributor \
  --scopes \
      /subscriptions/<subscription_id> \
  --sdk-auth
```

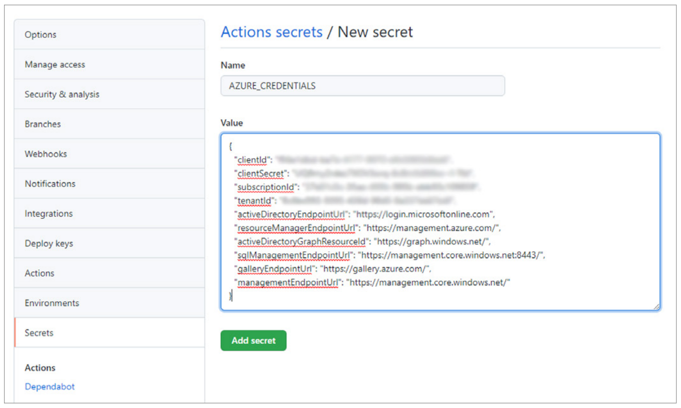
   This command will output the following:

```
{
  "clientId": <client_id>,
  "clientSecret": <client_secret>,
  "subscriptionId": <subscription_id>,
```

CODE CONTINUES IN NEXT COLUMN

```
  "tenantId": <tenent_id>,
  "activeDirectoryEndpointUrl": "https://
login.microsoftonline.com",
  "resourceManagerEndpointUrl": "https://
management.azure.com/",
  "activeDirectoryGraphResourceId": "https://
graph.windows.net/",
  "sqlManagementEndpointUrl": "https://
management.core.windows.net:8443/",
  "galleryEndpointUrl": "https://gallery.
azure.com/",
  "managementEndpointUrl": "https://
management.core.windows.net/"
}
```

8. Add a new secret, `AZURE_CREDENTIALS`, to our GitHub repository, under Settings → Secrets, as shown below:



Name

AZURE_CREDENTIALS

Value

```
{
  "clientId": [redacted]
  "clientSecret": [redacted]
  "subscriptionId": [redacted]
  "tenantId": [redacted]
  "activeDirectoryEndpointUrl": "https://login.microsoftonline.com",
  "resourceManagerEndpointUrl": "https://management.azure.com/",
  "activeDirectoryGraphResourceId": "https://graph.windows.net/",
  "sqlManagementEndpointUrl": "https://management.core.windows.net:8443/",
  "galleryEndpointUrl": "https://gallery.azure.com/",
  "managementEndpointUrl": "https://management.core.windows.net/"
}
```

9. Create the secrets for authenticating the container registry with our service principal:
   - Create a new secret, `REGISTRY_USERNAME`, with the value `<client_id>`
   - Create a new secret, `REGISTRY_PASSWORD`, with the value `<client_secret>`

With our Azure and GitHub environment configured, we can update our workflow to include a new job, `deploy`, that will be responsible for building our Docker image and deploying it to our Azure environment:

```
deploy:
  needs: unit-test
  runs-on: ubuntu-latest
  steps:
  - uses: actions/checkout@v2
  - name: Download JAR file
    uses: actions/download-artifact@v2
    with:
      name: jar-file
      path: target/
  - name: Login to Azure
    uses: azure/login@v1
```

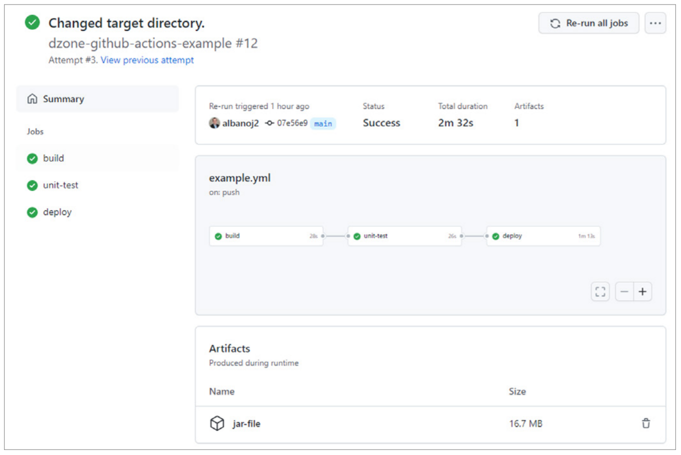
CODE CONTINUES ON NEXT PAGE

```
    with:
      creds: ${{ secrets.AZURE_CREDENTIALS }}
  - uses: azure/docker-login@v1
    with:
      login-server: albanoj2.azurecr.io
      username: ${{ secrets.REGISTRY_USERNAME }}
      password: ${{ secrets.REGISTRY_PASSWORD }}
  - run: |
      docker build -t albanoj2.azurecr.io/dzone-
github-actions-example:${{ github.sha }} .
      docker push albanoj2.azurecr.io/dzone-
github-actions-example:${{ github.sha }}
  - uses: azure/webapps-deploy@v2
    with:
      app-name: dzone-github-actions-example
      images: albanoj2.azurecr.io/dzone-github-
actions-example:${{ github.sha }}
  - name: Azure logout
    run: |
      az logout
```

Similar to our previous jobs, the **deploy** job runs after the **unit-test** job, executes using the latest Ubuntu image, and checks out the latest code from our repository, but there are also new steps:

1. **Download the JAR artifact** – Since each job is executed independently, a build has not been run in our **deploy** job. Therefore, we must download the artifacts that we uploaded in the **build** job to access our JAR artifact. Use the **path** field to specify that the JAR should be downloaded to **target/** (same directory that would contain the JAR file had we run a build).
2. **Log in to Azure** – We authenticate with Azure to run privileged commands later in the job. Note that the **login-server** value (**albanoj2.azurecr.io**) will be different for each user, depending on the value of **<login_server>** when setting up our Azure environment. See the Azure Docker Login action documentation for more information.
3. **Build a Docker image** – Our application will be deployed to Azure as a Docker container, so we must first build our Docker image. Once this image is built using our **Dockerfile**, we simply push it to our container registry — in this case, located at **albanoj2.azurecr.io**.
4. **Deploy the Docker image to Azure** – Lastly, we deploy the image we created in the prior step to our Azure deployment. Note that the **app-name** corresponds to the name of the App Service we created when we set up our Azure environment (i.e., **dzone-github-actions-example**). See the Azure WebApps Deploy action documentation for more information.

When we execute this workflow, we can see that our **deploy** job completes successfully (see screenshot in next column).


Changed target directory.
dzone-github-actions-example #12
Attempt #3. View previous attempt

Re-run triggered 1 hour ago — albanoj2 — 07e56e9 main
Status: Success
Total duration: 2m 32s
Artifacts: 1

example.yml
on: push

Artifacts
Produced during runtime

Name	Size
jar-file	16.7 MB

CONCLUSION

With our application deployed, we have now seen how to build an automated workflow that can build, test, and deploy applications each time we commit to our GitHub repositories. With GitHub Actions, we can create arbitrary workflows (CI/CD pipelines) that can automate our business needs. While the workflow we created is relatively simple, we can compose these fundamental concepts to create powerful pipelines that meet the needs of our large-scale production applications.

MORE INFORMATION

- Understanding GitHub Actions
- Workflow syntax for GitHub Actions
- GitHub Actions Marketplace
- What Is GitHub Actions for Azure
- Implement CI with Azure Pipelines and GitHub Actions
- Deploy to App Service using GitHub Actions

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