Scientific Calculator with DevOps

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1. Problem Statement

We need to create a scientific calculator program with user menu driven operations such as

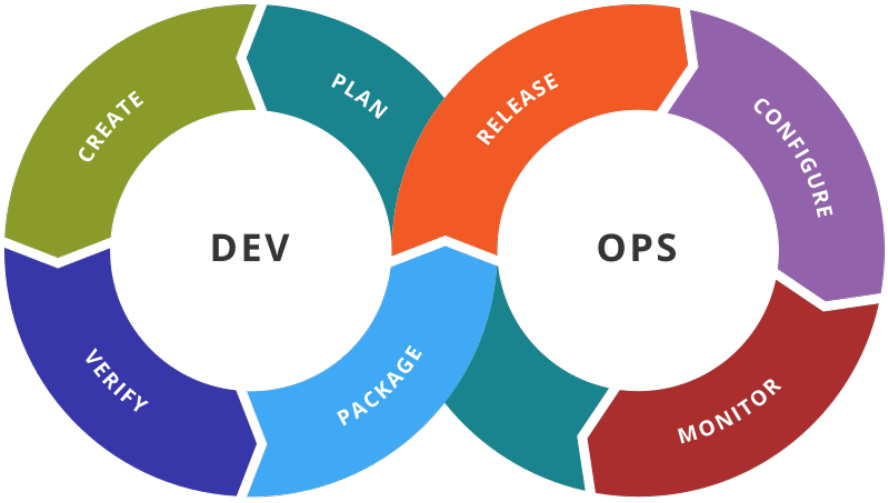
- Square root function - $\sqrt{x}$
- Factorial function - $x!$
- Natural logarithm (base e) - ln (x)
- Power function - x^y

We need to build the calculator with DevOps principles using any set of DevOps tool chain, but the pipeline should be same.

2. DevOps

2.1. What is DevOps?

DevOps is a collaborative method for creating and delivering software that unites teams from the development and operations departments to increase the efficiency and effectiveness of software releases. The software development lifecycle is streamlined using automation, continuous integration, and delivery (CI/CD), and agile approaches. The DevOps methodology places a strong emphasis on sharing responsibility, communication, and collaboration among all parties involved, including business teams, operations personnel, and developers. DevOps aims to produce high-quality software more quickly and reliably while cutting costs and risks.



2.2. Why DevOps?

Due to the increased demand for quicker, more reliable software delivery, DevOps has grown in importance in recent years. Long development cycles, manual testing, and siloed teams that operate independently from one another are frequent features of traditional software development processes. Delays, mistakes, and a lack of accountability may result from this.
By dismantling silos and promoting cooperation between the development and operations teams, DevOps overcomes these issues. DevOps enables teams to create software faster, more reliably, and with fewer errors by automating repetitive operations and optimizing the software development lifecycle. As a result, businesses can adapt to shifting market demands more rapidly, spend less money, and satisfy customers better.

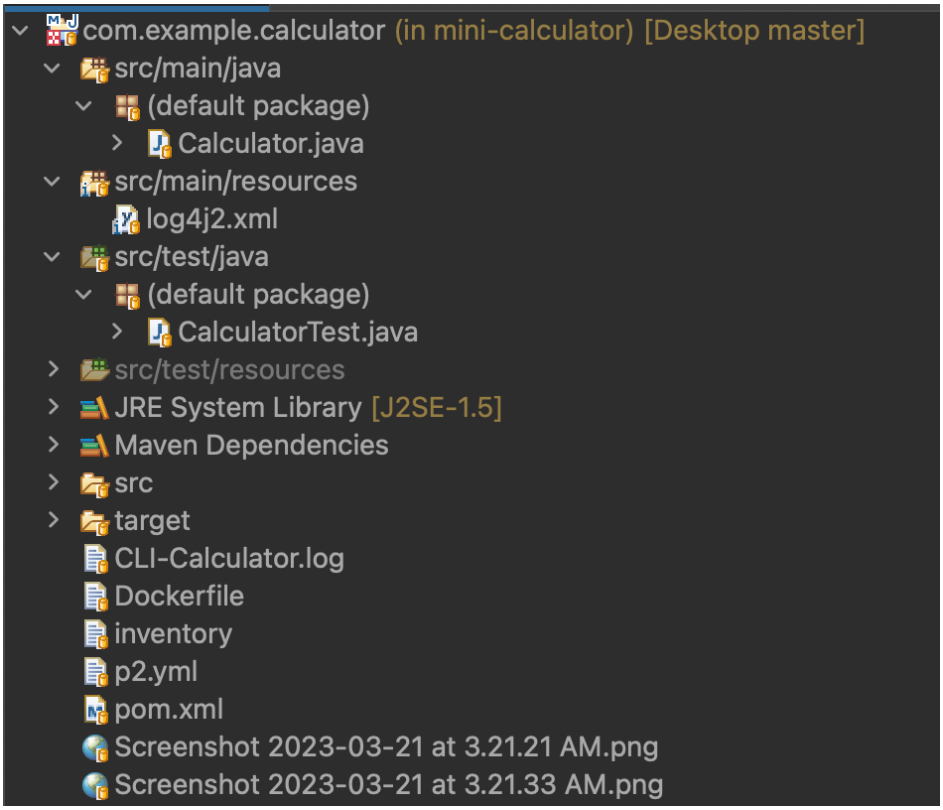
3. Tools Used

- **Git:** Used for version control.
- **GitHub:** Helps in source control management.
- **JUnit:** Used to test the code.
- **Maven:** Used to add dependencies and build the code as a jar file.
- **Jenkins:** Used for Continuous integration.
- **Docker:** Used for containerizing the code.
- **Docker Hub:** Used to host the docker images of the code.
- **Ansible:** Used to automate configuration management and deployment.
- **Elastic stack:** Used to monitoring. We generate a log file using log4j2 and use it for monitoring.
- **Ngrok and GitHub WebHooks:** Used to start the build process automatically whenever there is a new commit to the GitHub.

4. Steps

4.1. Developing, building, and testing the Calculator code

Firstly, install Java SE 8, maven, and Eclipse IDE and create a Maven project in the IDE. Add the dependencies JUnit, and log4j2 to the *pom.xml* file as we need them for testing and logging. Also add the compiler version to the *pom.xml* file to avoid errors in future steps. The images below show the same.



The project directory structure

```
<properties>
   <maven.compiler.source>1.8</maven.compiler.source>
   <maven.compiler.target>1.8</maven.compiler.target>
</properties>
```

Compiler version

```xml
<dependencies>
  <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>4.13.2</version>
      <scope>test</scope>
  </dependency>
  <dependency>
     <groupId>org.apache.logging.log4j</groupId>
     <artifactId>log4j-api</artifactId>
     <version>2.14.0</version>
  </dependency>
  <dependency>
     <groupId>org.apache.logging.log4j</groupId>
     <artifactId>log4j-core</artifactId>
     <version>2.14.0</version>
  </dependency>
</dependencies>
```

Dependencies

```xml
<build>
  <plugins>
      <plugin>
      <!-- Build an executable JAR --> <groupId>org.apache.maven.plugins</groupId> <artifactId>maven-jar-plug
      <configuration>
      <archive> <manifest>
      <mainClass>Calculator</mainClass> </manifest>
      </archive> </configuration>
      </plugin>

      <plugin>
          <groupId>org.apache.maven.plugins</groupId>
          <artifactId>maven-assembly-plugin</artifactId>
          <executions>
              <execution>
                  <phase>package</phase>
                  <goals>
                      <goal>single</goal>
                  </goals>
                  <configuration>
                      <archive>
                          <manifest>
                              <mainClass>calculator.Calculator</mainClass>
                          </manifest>
                      </archive>
                      <descriptorRefs>
                          <descriptorRef>jar-with-dependencies</descriptorRef>
                      </descriptorRefs>
                  </configuration>
              </execution>
          </executions>
      </plugin>

  </plugins>
</build>
```

To build the project as a jar file

The *Calculator.java* file contains the main functionality code. It also contains the logging statements which are used while generating log file which in turn is used for monitoring.

```
public double factorial(double val)
{
    double ans = 1;

    if(val <0)
    {
        logger.error("[FACTORIAL] - " + val);
        logger.error("[RESULT - FACTORIAL] - " + "null");
        ans = -1;
    }

    else
    {
        for(int i=1; i<=val; i++)
            ans *= i;
        logger.info("[FACTORIAL] - " + val);
        logger.info("[RESULT - FACTORIAL] - " + ans);
    }

    return ans;
}

public double logarithm(double val)
{
    double ans;
    if(val <=0) {
        ans = -1;
        logger.error("[LOGARITHM] - " + val);
        logger.error("[RESULT - LOGARITHM] - " + "null");
    }

    else
    {
        ans = Math.log(val);
        logger.info("[LOGARITHM] - " + val);
        logger.info("[RESULT - LOGARITHM] - " + ans);
    }

    return ans;
}
```

The functions for factorial and natural logarithm

The *CalculatorTest.java* contains the test cases used for testing purposes. It has both TruePositive and FalsePositve test cases for all the 4 functions. The *log4j2.xml* is used for generating the log file.

```
@Test
public void factorialTruePositive(){
    assertEquals("Finding factorial of a number for True positive",2,calc.factorial(2), delta);
    assertEquals("Finding factorial of a number for True positive",120,calc.factorial(5), delta);
    assertEquals("Finding factorial of a number for True positive",40320,calc.factorial(8), delta);
    assertEquals("Finding factorial of a number for True positive",720,calc.factorial(6), delta);

}

@Test
public void factorialFalsePositive(){
    assertNotEquals("Finding factorial of a number for False Positive",100,calc.factorial(5),delta);
    assertNotEquals("Finding factorial of a number for False positive",47,calc.factorial(4), delta);
    assertNotEquals("Finding factorial of a number for False positive",18,calc.factorial(6), delta);
}


@Test
public void logarithmTruePositive(){
    assertEquals("Finding Natural Logarithm of a number for True positive",Math.log(7),calc.logarithm(7), delta
    assertEquals("Finding Natural Logarithm of a number for True positive",Math.log(4.7),calc.logarithm(4.7),
    assertEquals("Finding Natural Logarithm of a number for True positive",Math.log(16),calc.logarithm(16), de
}

@Test
public void logarithmFalsePositive(){
    assertNotEquals("Finding Natural Logarithm of a number for False positive",5,calc.logarithm(7), delta);
    assertNotEquals("Finding Natural Logarithm of a number for False positive",3,calc.logarithm(5), delta);
    assertNotEquals("Finding Natural Logarithm of a number for False positive",2,calc.logarithm(2), delta);
}
```

Test cases for the 4 functions.

After writing the code, use *mvn clean install* command to build the code. It also tests the code using the written test cases. This will create a new folder “target” and .jar file inside it.

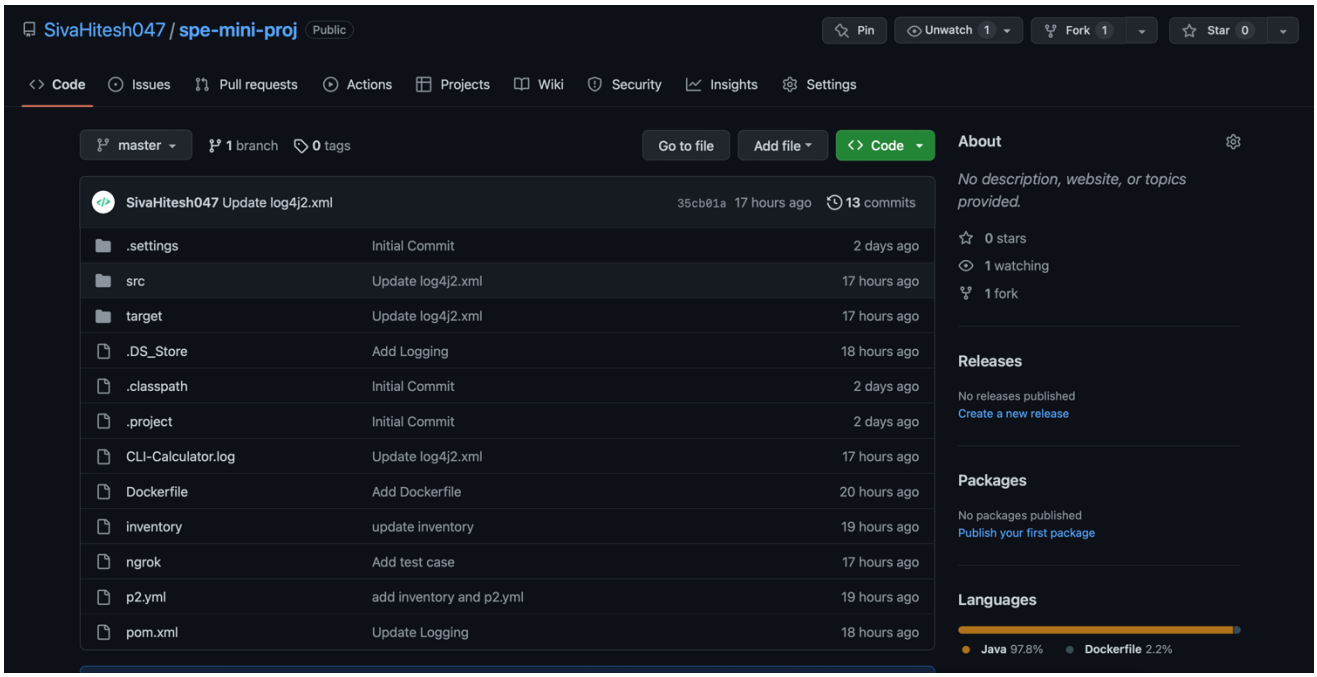
```
[INFO]
[INFO] --- maven-install-plugin:2.4:install (default-install) @ com.example.calculator ---
[INFO] Installing /Users/sivahitesh/Desktop/mini-calculator/target/com.example.calculator-0.0.1-SNAP
SHOT.jar to /Users/sivahitesh/.m2/repository/com/example/calculator/com.example.calculator/0.0.1-SNA
PSHOT/com.example.calculator-0.0.1-SNAPSHOT.jar
[INFO] Installing /Users/sivahitesh/Desktop/mini-calculator/pom.xml to /Users/sivahitesh/.m2/reposit
ory/com/example/calculator/com.example.calculator/0.0.1-SNAPSHOT/com.example.calculator-0.0.1-SNAPSH
OT.pom
[INFO] Installing /Users/sivahitesh/Desktop/mini-calculator/target/com.example.calculator-0.0.1-SNAP
SHOT-jar-with-dependencies.jar to /Users/sivahitesh/.m2/repository/com/example/calculator/com.exampl
e.calculator/0.0.1-SNAPSHOT/com.example.calculator-0.0.1-SNAPSHOT-jar-with-dependencies.jar
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time:  4.121 s
[INFO] Finished at: 2023-03-21T20:13:14+05:30
[INFO] ------------------------------------------------------------------------
```

mvn clean install output

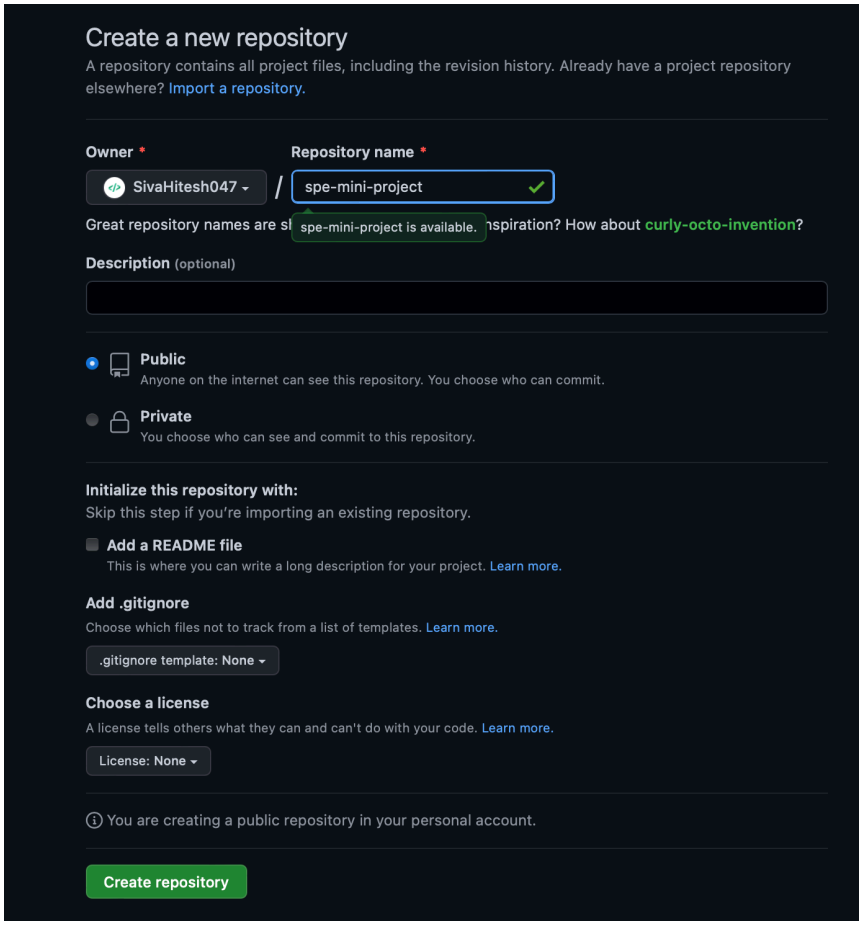
4.2. Pushing the code to GitHub

Create a Personal access token in GitHub from the *Developer Settings*. Then, create a repository in GitHub and push the code to that repository from the local folder using the following commands:

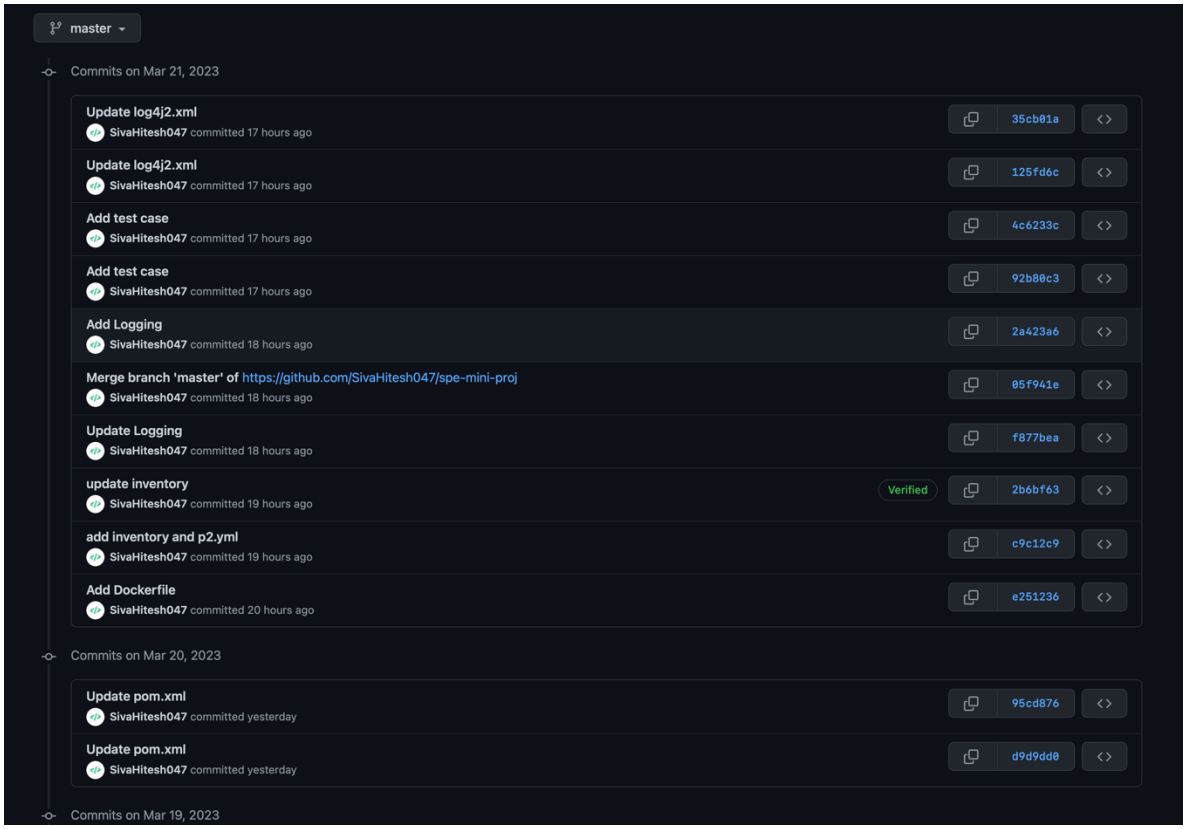
- $ Git init
- $ git add .
- $ git commit -m “Commit Message.”
- $ git push https://[USERNAME]:[ACCESSTOKEN]@github.com/[USERNAME]/[REPO].git



GitHub Repository



Creating a Repo



The Commit messages.

4.3. Creating the pipeline in Jenkins

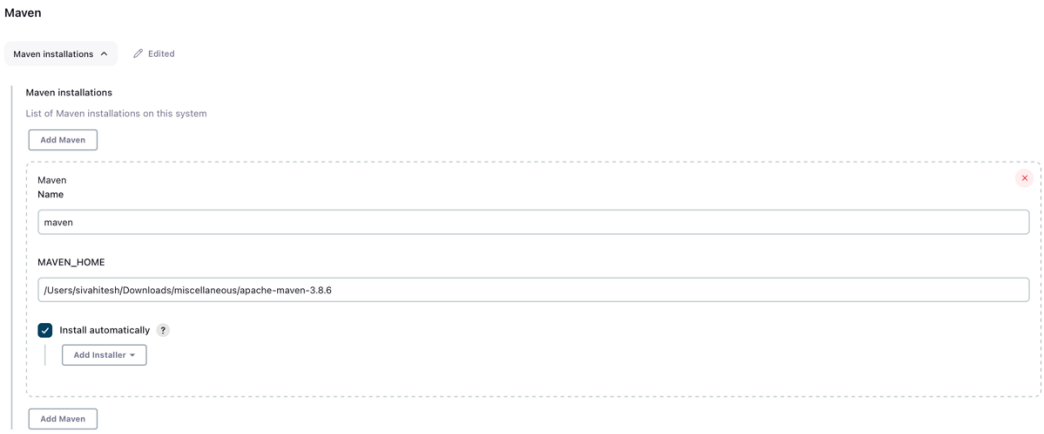
Jenkins is a continuous integration/continuous delivery and deployment (CI/CD) automation software. It is a very useful DevOps tool and is written in Java language. Install the Jenkins via *homebrew* package using the following commands:

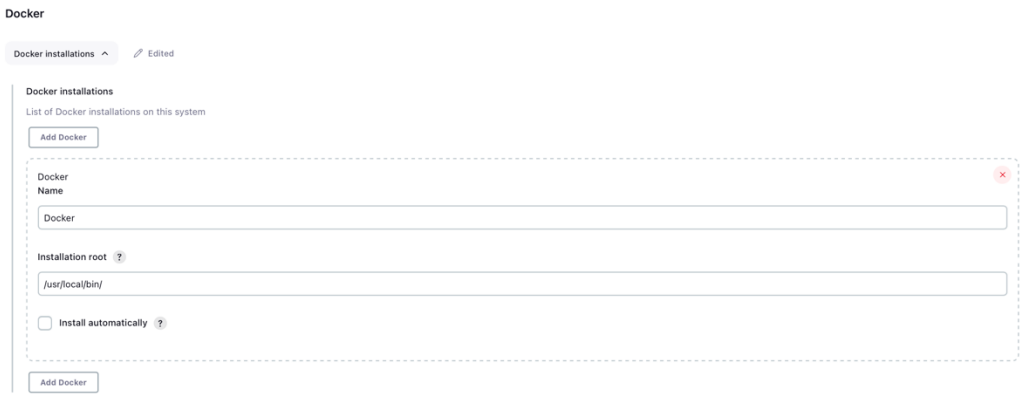
- Install the latest LTS version: brew install jenkins-lts
- Install a specific LTS version: brew install jenkins-lts@YOUR_VERSION
- Start the Jenkins service: brew services start jenkins-lts
- Restart the Jenkins service: brew services restart jenkins-lts
- Update the Jenkins version: brew upgrade jenkins-lts

After starting the Jenkins service, go to http://localhost:8080 and finish the setup. Install the following plugins that are required for the project in **Manage Plugins**:

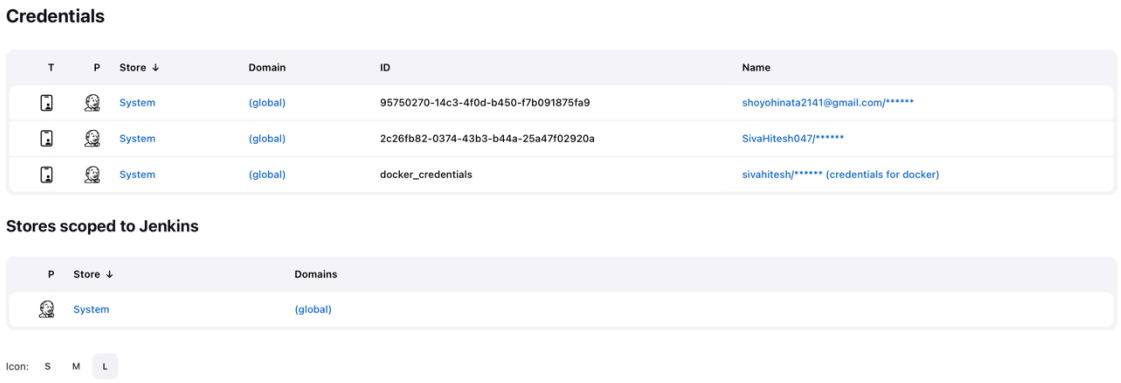
- Git
- Maven
- Docker
- Ansible

We need to configure these in **Global tool Configuration**. The path given should be the same as the path where the tool is located in the local system. It can be found using $*whereis mvn* command.

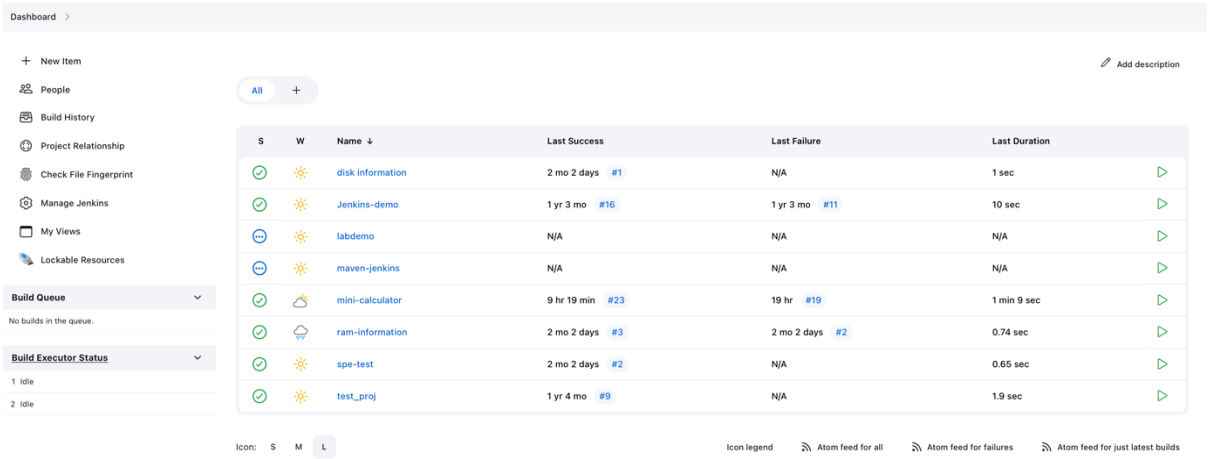




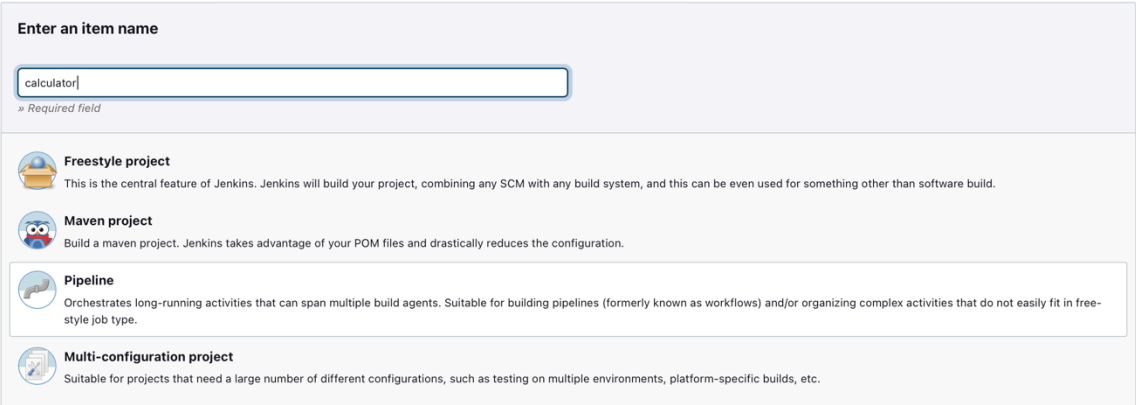
For Jenkins to access the repositories, we give the credentials in **Manage Credentials**.



Now, Create a pipeline project from the Jenkins dashboard.



Jenkins Dashboard



Creating Pipeline Project

4.3.1. The Pipeline

- **Git Pull:** This stage pulls the repository from GitHub.

```
stage('Git Pull stage') {
    steps {
        // Get some code from a GitHub repository
        git 'https://github.com/SivaHitesh047/spe-mini-proj.git'
    }
}
```

- **Maven Build:** This stage builds the project again and generates a new jar file deleting the existing one.

```
environment{
    PATH = "/Users/sivahitesh/Downloads/miscellaneous/apache-maven-3.8.6/bin:$PATH"
}
agent any

stage('Maven Build'){
    steps{
        script{
            sh 'mvn clean install'

        }
    }
}
```

- **Docker Build Image:** This stage is used to build the docker image of the project.

```
stage('Docker Build Image')
{
    steps{
        script{
            imageName = docker.build "sivahitesh/scientific-calculator:latest"
        }
    }
}
```

- **Push Docker Image:** In this stage, we deploy the existing docker image to the DockerHub repository.

```
stage('Push Docker Image')
{
    steps{
        script{
            docker.withRegistry("", 'docker_credentials' ){
                imageName.push()
            }
        }
    }
}
```

- **Ansible Deployment:** This is used to pull the docker image from the DockerHub and deploy it on every machine mentioned in Inventory file.

```
stage('Ansible pull docker image')
{
    steps{
        sh "/usr/bin/pip3 install docker"
        sh "/usr/bin/pip3 install requests"
        sh "ansible-playbook p2.yml -i inventory"
    }
}
```

Pipeline Builds

4.4. Containerization

We use docker for Containerization. Docker is a platform for developing, packaging, and deploying applications in a containerized environment. It packages software and all its dependencies into a portable unit, making it easy to move between different environments.

We need to create a docker image and push it to the DockerHub. Create a file named Dockerfile. In this, we'll use the jar file to create the image.

```
FROM openjdk:8
COPY ./target/com.example.calculator-0.0.1-SNAPSHOT.jar ./
WORKDIR ./
CMD ["java", "-cp", "com.example.calculator-0.0.1-SNAPSHOT.jar", "Calculator"]
```

- FROM imports the base image of jdk8 for creating a new image.
- COPY copies the jar file into the image in its root directory.
- WORKDIR changes the current working directory.
- CMD runs the command inside the image.

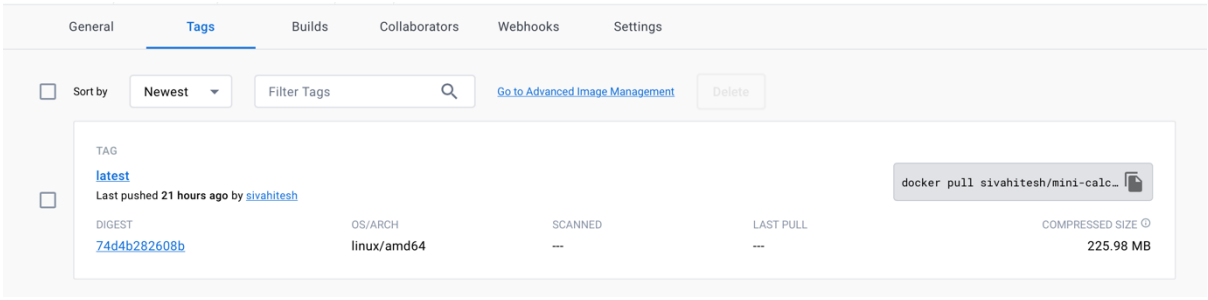
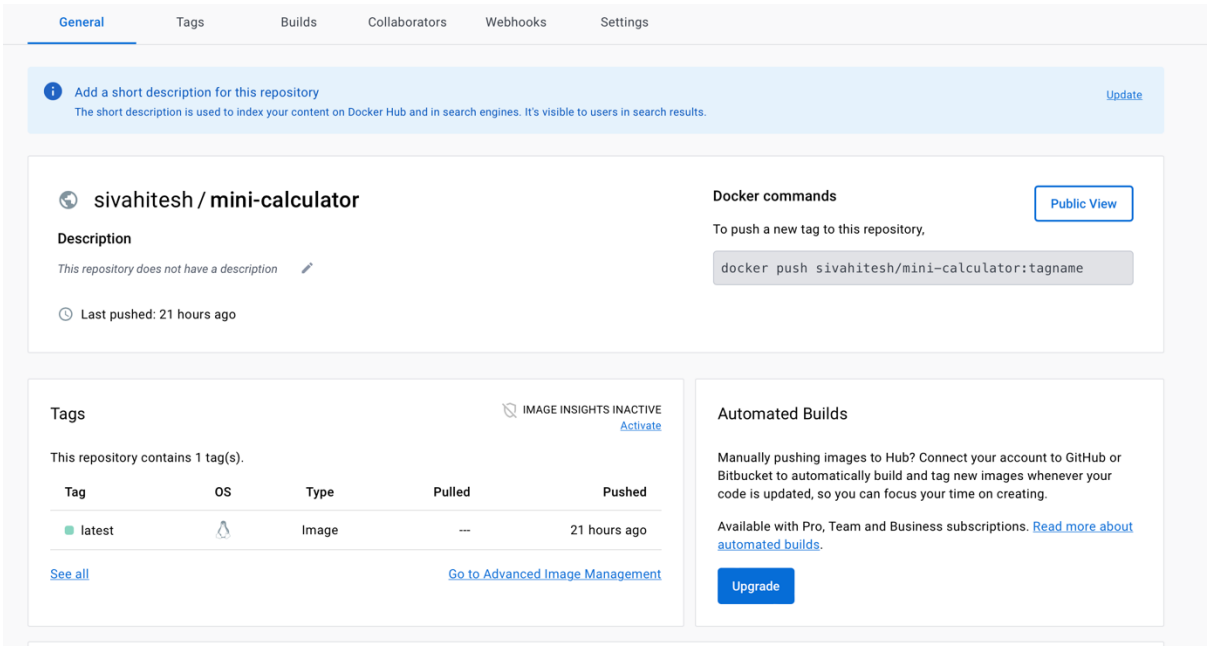


Image in the DockerHub



DockerHub Repository

4.5. Deployment

We use Ansible tool for deployment. Ansible is an automation tool used for configuration management, application deployment, and task automation. It uses a simple syntax called YAML to define tasks and playbooks that can be executed on multiple servers simultaneously.

Install ansible using command $*brew install ansible.*

```
> sivahitesh > Desktop > mini-calculator > inventory
localhost ansible_user=sivahitesh ansible_connection=local ansible_python_interpreter=/usr/bin/python3
```

Inventory file

```yaml
---
- name: pull mini_project image
  hosts: all
  tasks:
        - name: Pull devops image
          docker_image:
                name: sivahitesh/mini-calculator
                source: pull

        - name: creating updated container
          shell: docker run -id sivahitesh/mini-calculator
```

The Playbook p2.yml.

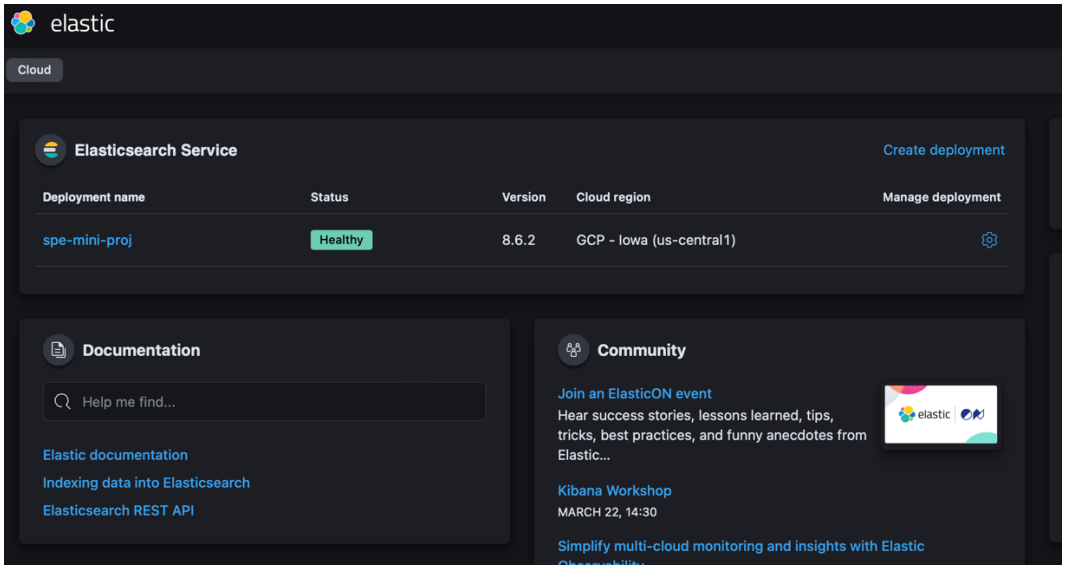
4.6. Monitoring using ELK stack

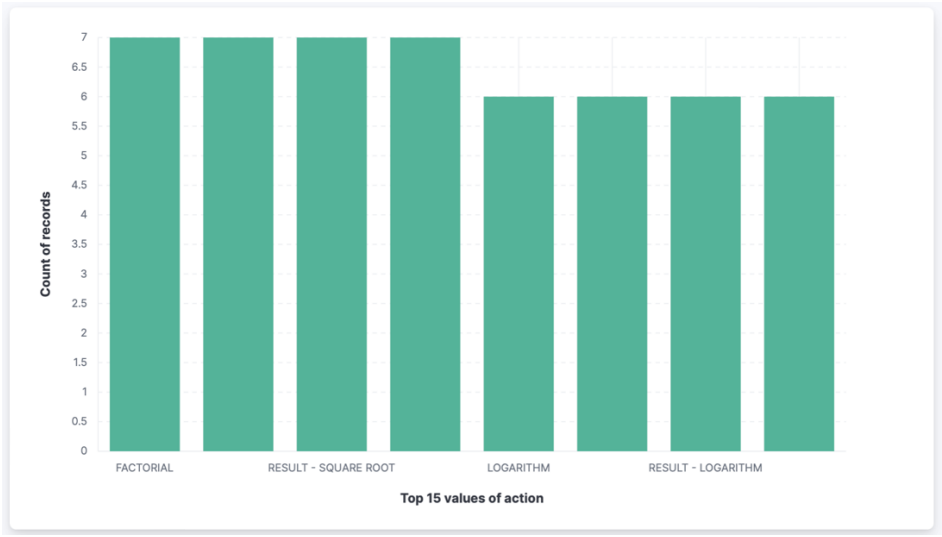
Monitoring should be done once the deployment. It must be done to measure the performance of the various components of a software system to ensure that it is functioning correctly and efficiently.

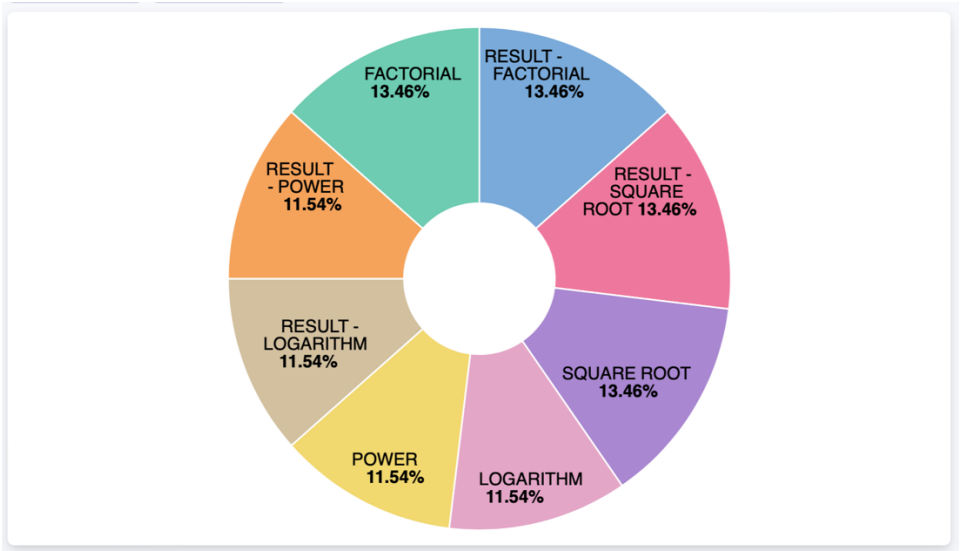
The ELK stack is an open-source toolset for collecting, analyzing, and visualizing large volumes of data in real-time. It consists of three main components: Elasticsearch, Logstash, and Kibana. Together, these tools provide a powerful solution for managing and analyzing log data.

```
(base) sivahitesh@Siva-Hiteshs-MacBook-Pro mini-calculator % cat CLI-Calculator.log
21/03/2023:03:13:47 716 [Calculator.java] [INFO] Calculator [FACTORIAL] - 5.0
21/03/2023:03:13:47 721 [Calculator.java] [INFO] Calculator [RESULT - FACTORIAL] - 120.0
21/03/2023:03:13:47 722 [Calculator.java] [INFO] Calculator [FACTORIAL] - 4.0
21/03/2023:03:13:47 722 [Calculator.java] [INFO] Calculator [RESULT - FACTORIAL] - 24.0
21/03/2023:03:13:47 722 [Calculator.java] [INFO] Calculator [FACTORIAL] - 6.0
21/03/2023:03:13:47 723 [Calculator.java] [INFO] Calculator [RESULT - FACTORIAL] - 720.0
21/03/2023:03:13:47 723 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 25.0
21/03/2023:03:13:47 724 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 5.0
21/03/2023:03:13:47 724 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 16.0
21/03/2023:03:13:47 724 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 4.0
21/03/2023:03:13:47 725 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 169.0
21/03/2023:03:13:47 725 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 13.0
21/03/2023:03:13:47 725 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 36.0
21/03/2023:03:13:47 725 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 6.0
21/03/2023:03:13:47 726 [Calculator.java] [INFO] Calculator [LOGARITHM] - 7.0
21/03/2023:03:13:47 726 [Calculator.java] [INFO] Calculator [RESULT - LOGARITHM] - 1.9459101490553132
21/03/2023:03:13:47 727 [Calculator.java] [INFO] Calculator [LOGARITHM] - 4.7
21/03/2023:03:13:47 727 [Calculator.java] [INFO] Calculator [RESULT - LOGARITHM] - 1.547562508716013
21/03/2023:03:13:47 727 [Calculator.java] [INFO] Calculator [LOGARITHM] - 16.0
21/03/2023:03:13:47 727 [Calculator.java] [INFO] Calculator [RESULT - LOGARITHM] - 2.772588722239781
21/03/2023:03:13:47 728 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 10.0
21/03/2023:03:13:47 728 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 3.1622776601683795
21/03/2023:03:13:47 729 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 25.0
21/03/2023:03:13:47 729 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 5.0
21/03/2023:03:13:47 729 [Calculator.java] [INFO] Calculator [SQUARE ROOT] - 36.0
21/03/2023:03:13:47 729 [Calculator.java] [INFO] Calculator [RESULT - SQUARE ROOT] - 6.0
21/03/2023:03:13:47 730 [Calculator.java] [INFO] Calculator [FACTORIAL] - 2.0
```

Log file


elastic
Cloud
Elasticsearch Service
Create deployment
Deployment name
Status
Version
Cloud region
Manage deployment
spe-mini-proj
Healthy
8.6.2
GCP - Iowa (us-central1)
Documentation
Help me find...
Elastic documentation
Indexing data into Elasticsearch
Elasticsearch REST API
Community
Join an ElasticON event
Hear success stories, lessons learned, tips, tricks, best practices, and funny anecdotes from Elastic...
Kibana Workshop
MARCH 22, 14:30
Simplify multi-cloud monitoring and insights with Elastic


Count of records
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
FACTORIAL
RESULT - SQUARE ROOT
LOGARITHM
RESULT - LOGARITHM
Top 15 values of action

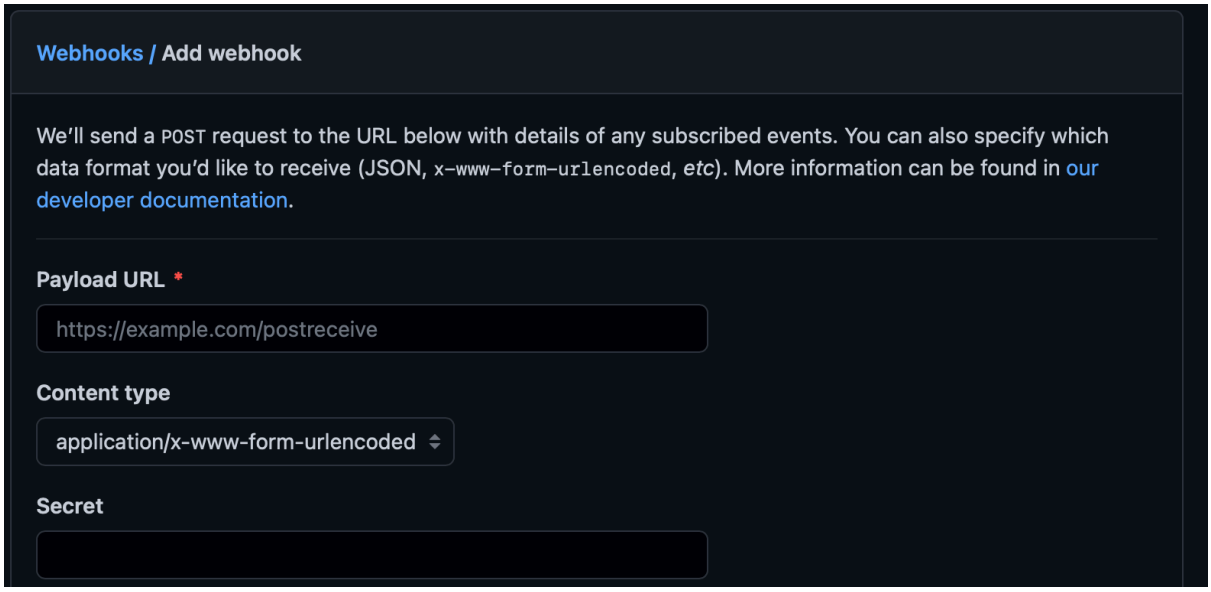

FACTORIAL 13.46%
RESULT - FACTORIAL 13.46%
RESULT - POWER 11.54%
RESULT - SQUARE ROOT 13.46%
RESULT - LOGARITHM 11.54%
SQUARE ROOT 13.46%
POWER 11.54%
LOGARITHM 11.54%

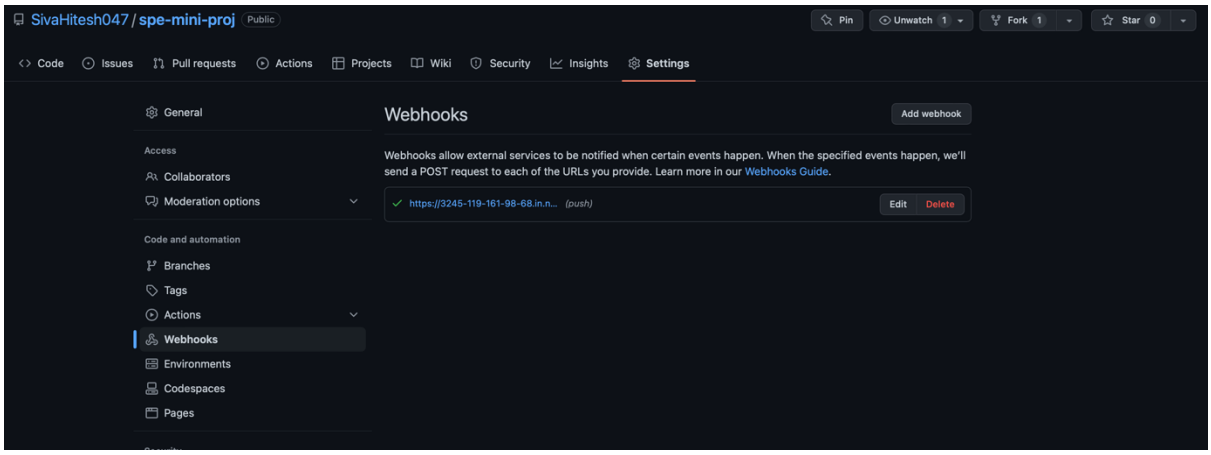
4.7. WebHooks

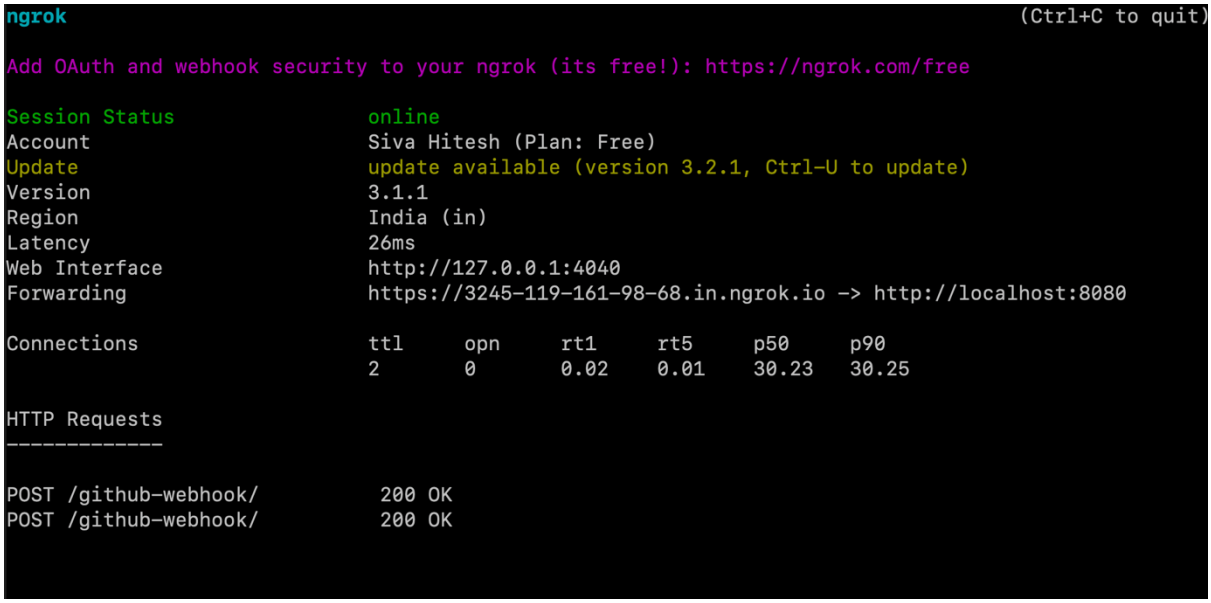
Webhooks are automated messages that are sent from a web application to a designated URL when a specific event occurs. The Webhook will build the Jenkins pipeline automatically if we make any new commit to the GitHub repo.

Ngrok creates a secure tunnel between the developer's machine and the internet, which allows external users to access the web server through a unique URL generated by Ngrok. It is commonly used for testing webhooks, APIs, and other web services locally before deploying them to a production environment.

- Install ngrok using $ *brew install ngrok/ngrok/ngrok*
- Start it using ngrok http 8080;
- Go to the Webhooks in repository settings and add ngrok address in payload url and the personal access token in secret.







5. Challenges

I got docker command not found while building the Jenkins pipeline and I had to add the following to /usr/local/Cellar/jenkins-lts/2.176.3/homebrew.mxcl.jenkins-lts.plist file:

```
<key>EnvironmentVariables</key>
  <dict>
   <key>PATH</key>
  <string>/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin:/Applications/Docker.app/Contents/Resources/bin/:/Users/Kh0a/Library/Group\
Containers/group.com.docker/Applications/Docker.app/Contents/Resources/bin
  </string>
  </dict>
```

I also got mvn command not found and had to add Path to the environment in the pipeline script. Alongside doing these I needed to set the path in Global Tool Configuration for both Maven and docker.

6. Links

Link to the GitHub Repo:

https://github.com/SivaHitesh047/spe-mini-proj.git

Link to the DockerHub Repo:

https://hub.docker.com/repository/docker/sivahitesh/scientific-calculator/general