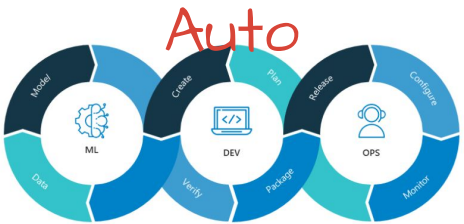
Google Cloud

AutoMLOps

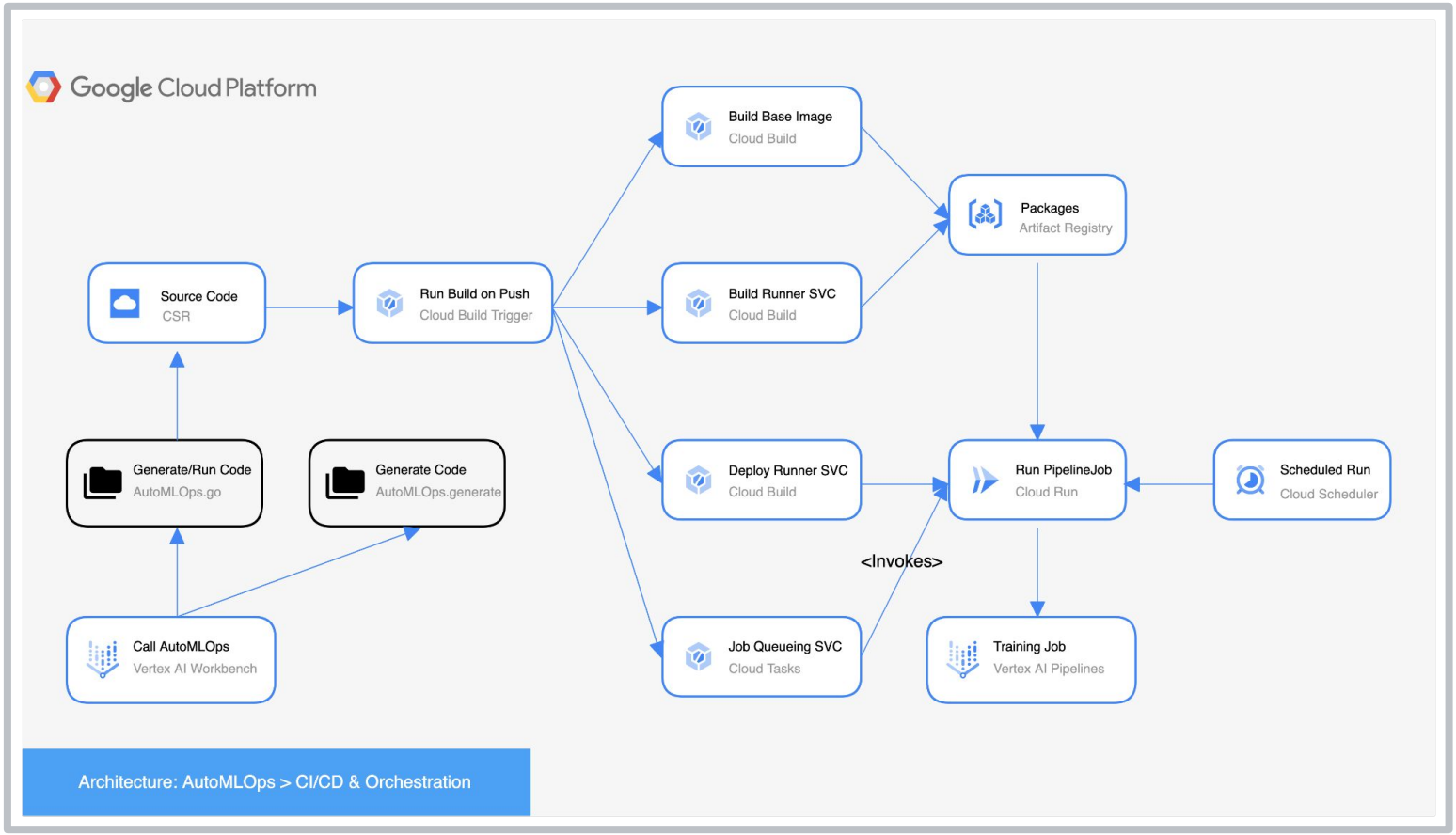
From Notebooks to Pipelines in Minutes

Implementation Guide



automlops@
July 2023

Solution Overview



Set Up

Prerequisites / Assumptions

The prerequisites for use of AutoMLOps are as follows:

- Python version ≥3.7 and ≤3.10
- Google Cloud SDK 407.0.0
- gcloud beta 2022.10.21
- git is installed and logged-in

```
git config --global user.email "you@example.com"
git config --global user.name "Your Name"
```

- Application Default Credentials (ADC) are set up, which can be done through the following commands:

```
gcloud auth application-default login
gcloud config set account <account@example.com>
```

Set Up AutoMLOps Package

1. Install the AutoMLOps package:

```
pip install google-cloud-automlops
```

2. Import the AutoMLOps package:

```
from AutoMLOps import AutoMLOps
```

3. Decide whether to use Kubeflow definitions or Python definitions

Using Python Components (no Kubeflow)

AutoMLOps Python Definition

1. Define a component

```
@AutoMLOps.component
def create_dataset(
   bq_table: str,
   data_path: str,
   project_id: str
):
   """Custom component that takes in a BQ table and
      writes it to GCS.

   Args:
       bq_table: The source biquery table.
       data_path: The gcs location to write the csv.
       project_id: The project ID.
   """
   from google.cloud import bigquery
   import pandas as pd
   ...
```

- Wrap your code into a function
- Provide input parameters and specify their types
- (Optionally) Specify a docstring with parameter descriptions
- Include required imports inside of the function
- Use @AutoMLOps.component decorator to specify a component. This will automatically containerize your code, creating a separate python file, dockerfile, requirements.txt, and a component specification yaml
- Repeat this process for each component

AutoMLOps Python Definition

2. Define a pipeline

- Define a function for your pipeline definition
  - Provide pipeline input parameters and specify their types
- Chain together all components
  - Use .after(...) to specify the order of execution for the pipeline
- Link the pipeline parameters to their matching component parameters
- (Optionally) Provide a name and description for the pipeline
- Use @AutoMLOps.pipeline decorator to specify the pipeline. This will automatically turn your function into a pipeline

```
@AutoMLOps.pipeline #(name='automlops-pipeline', description='This is an optional description')
def pipeline(bq_table: str,
             model_directory: str,
             data_path: str,
             project_id: str,
             region: str,
            ):

    create_dataset_task = create_dataset(
        bq_table=bq_table,
        data_path=data_path,
        project_id=project_id)

    train_model_task = train_model(
        model_directory=model_directory,
        data_path=data_path).after(create_dataset_task)

    deploy_model_task = deploy_model(
        model_directory=model_directory,
        project_id=project_id,
        region=region).after(train_model_task)
```

AutoMLOps Python Definition

4. Define the pipeline parameters dictionary

```
pipeline_params = {
    "bq_table": f"{PROJECT_ID}.test_dataset.dry-beans",
    "model_directory": f"gs://{PROJECT_ID}-bucket/trained_models/{datetime.datetime.now()}",
    "data_path": f"gs://{PROJECT_ID}-bucket/data",
    "project_id": f"{PROJECT_ID}",
    "region": "us-central1"
}
```

AutoMLOps Python Definition

5. Call ***AutoMLOps.generate()*** to create the resources and repository

   Or ***AutoMLOps.go()*** to call generate in addition to building/submitting the pipeline job

```
AutoMLOps.generate(project_id = PROJECT_ID,
                   pipeline_params = pipeline_params,
                   run_local = True)

AutoMLOps.go(project_id = PROJECT_ID,
             pipeline_params = pipeline_params,
             run_local = True)
```

   Set ***run_local=False*** if you want to generate and use CI/CD features

Using Kubeflow Components

AutoMLOps Kubeflow Definition

1. Define your components using KFP

```
from kfp.v2 import dsl


@dsl.component(
   packages_to_install = [
       "google-cloud-bigquery",
       "pandas",
       "pyarrow",
       "db_dtypes"
   ],
   base_image = "python:3.9",
   output_component_file = f"{AutoMLOps.OUTPUT_DIR}/create_dataset.yaml"
)
def create_dataset(
   bq_table: str,
   output_data_path: OutputPath("Dataset"),
   project: str
):
   from google.cloud import bigquery
...
```

AutoMLOps Kubeflow Definition

2. Define a pipeline

- Define a function for your pipeline definition
  - Provide pipeline input parameters and specify their types
- Chain together all components
  - Use .after(...) to specify the order of execution for the pipeline
- Link the pipeline parameters to their matching component parameters
- (Optionally) Provide a name and description for the pipeline
- Use @AutoMLOps.pipeline decorator to specify the pipeline. This will automatically turn your function into a pipeline

```
@AutoMLOps.pipeline
def pipeline(bq_table: str,
             output_model_directory: str,
             project: str,
             region: str,
            ):

    dataset_task = create_dataset(
        bq_table=bq_table,
        project=project)

    model_task = train_model(
        output_model_directory=output_model_directory,
        dataset=dataset_task.output)

    deploy_task = deploy_model(
        model=model_task.outputs["model"],
        project=project,
        region=region)
```

AutoMLOps Kubeflow Process

3. Define the pipeline parameters dictionary

```
pipeline_params = {
   "bq_table": f"{PROJECT_ID}.test_dataset.dry-beans",
   "output_model_directory": f"gs://{PROJECT_ID}-bucket/trained_models/{datetime.datetime.now()}",
   "project": f"{PROJECT_ID}",
   "region": "us-central1"
}
```

AutoMLOps Kubeflow Process

4. Call ***AutoMLOps.generate()*** to create the resources and repository

   Or ***AutoMLOps.go()*** to call generate in addition to building/submitting the pipeline job

```
AutoMLOps.generate(project_id = PROJECT_ID,
                   pipeline_params = pipeline_params,
                   run_local = False)

AutoMLOps.go(project_id = PROJECT_ID,
             pipeline_params = pipeline_params,
             run_local = False)
```

   Set ***run_local=False*** if you want to generate and use CI/CD features

Customizations

AutoMLOps Defaults

There are a number of custom parameters that can be configured. To the left is a list of the default parameters:

```
AutoMLOps.go(project_id=PROJECT_ID, # required
             pipeline_params=pipeline_params, # required
             af_registry_location='us-central1', # default
             af_registry_name='vertex-mlops-af', # default
             base_image='python:3.9-slim', # default
             cb_trigger_location='us-central1', # default
             cb_trigger_name='automlops-trigger', # default
             cloud_run_location='us-central1', # default
             cloud_run_name='run-pipeline', # default
             cloud_tasks_queue_location='us-central1', # default
             cloud_tasks_queue_name='queueing-svc', # default
             csr_branch_name='automlops', # default
             csr_name='AutoMLOps-repo', # default
             custom_training_job_specs=None, # default
             gs_bucket_location='us-central1', # default
             gs_bucket_name=None, # default
             pipeline_runner_sa=None, # default
             run_local=True, # default
             schedule_location='us-central1', # default
             schedule_name='AutoMLOps-schedule', # default
             schedule_pattern='No Schedule Specified', # default
             vpc_connector='No VPC Specified' # default)
```

AutoMLOps Defaults

- `project_id`: The project ID.
- `pipeline_params`: Dictionary containing runtime pipeline parameters.
- `af_registry_location`: Region of the Artifact Registry.
- `af_registry_name`: Artifact Registry name where components are stored.
- `base_image`: The image to use in the component base dockerfile.
- `cb_trigger_location`: The location of the cloudbuild trigger.
- `cb_trigger_name`: The name of the cloudbuild trigger.
- `cloud_run_location`: The location of the cloud runner service.
- `cloud_run_name`: The name of the cloud runner service.
- `cloud_tasks_queue_location`: The location of the cloud tasks queue.
- `cloud_tasks_queue_name`: The name of the cloud tasks queue.
- `csr_branch_name`: The name of the csr branch to push to to trigger cb job.
- `csr_name`: The name of the cloud source repo to use.
- `custom_training_job_specs`: Specifies the specs to run the training job with.
- `gs_bucket_location`: Region of the GS bucket.
- `gs_bucket_name`: GS bucket name where pipeline run metadata is stored.
- `pipeline_runner_sa`: Service Account to runner PipelineJobs.
- `run_local`: Flag that determines whether to use Cloud Run CI/CD.
- `schedule_location`: The location of the scheduler resource.
- `schedule_name`: The name of the scheduler resource.
- `schedule_pattern`: Cron formatted value used to create a Scheduled retrain job.
- `vpc_connector`: The name of the vpc connector to use.

AutoMLOps Set Scheduled Run

Use the ***schedule_pattern*** parameter to specify a cron job schedule to run the pipeline job on a recurring basis.

The ***run_local*** must be set to ***False*** to make use of this feature.

```
AutoMLOps.generate(project_id = PROJECT_ID,
                   pipeline_params = pipeline_params,
                   run_local = False,
                   schedule_pattern = '0 */12 * * *')
```

The above example will rerun the pipeline every 12 hours.

AutoMLOps Set Pipeline Compute Resources

Use the ***base_image*** and ***custom_training_job_specs*** parameters to specify resources for any custom component in the pipeline.

The ***component_spec*** must match exactly the name of the custom component.

```
AutoMLOps.generate(project_id = PROJECT_ID,
                   pipeline_params = pipeline_params,
                   run_local = False,
                   base_image = 'us-docker.pkg.dev/vertex-ai/training/tf-gpu.2-11.py310:latest',
                   custom_training_job_specs = [{
                      'component_spec': 'train_model',
                      'display_name': 'train-model-accelerated',
                      'machine_type': 'a2-highgpu-1g',
                      'accelerator_type': 'NVIDIA_TESLA_A100',
                      'accelerator_count': '1'
                   }])
```

The example above uses a GPU for accelerated training. See Machine types and GPUs for more info.

The ***custom_training_job_specs*** parameter takes in any key-value pair available under

google_cloud_pipeline_components.v1.custom_job.create_custom_training_job_op_from_component

AutoMLOps VPC Connector

Use the ***vpc_connector*** parameter to specify a vpc connector.

```
AutoMLOps.generate(project_id = PROJECT_ID,
                   pipeline_params = pipeline_params,
                   run_local = False,
                   vpc_connector = 'example-vpc')
```

AutoMLOps Specify package versions

Use the ***packages_to_install*** parameter of ***@AutoMLOps.component*** to explicitly specify packages and versions.

You wish to use for your component. AutoMLOps will infer these package requirements otherwise.

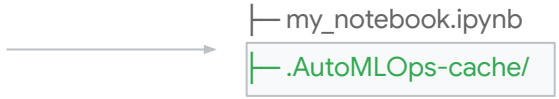
```
@AutoMLOps.component(
    packages_to_install=[
        "google-cloud-bigquery==2.34.4",
        "pandas",
        "pyarrow",
        "db_dtypes"
    ]
)
def create_dataset(
    bq_table: str,
    data_path: str,
    project_id: str
):
...
```

Behind the Scenes

Importing AutoMLOps

Importing the AutoMLOps package will create a cache subdirectory within the same directory as the file where the import statement is called:

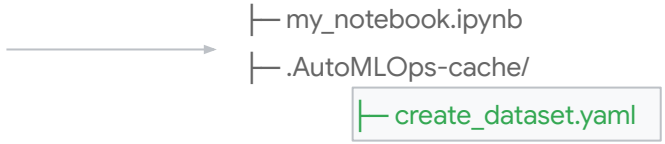
```
from AutoMLOps import AutoMLOps
```



Defining an AutoMLOps Component

Defining an AutoMLOps component will create a corresponding temporary file within the cache subdirectory:

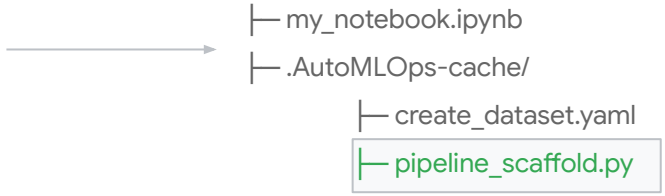
```
@AutoMLOps.component
def create_dataset(
   bq_table: str,
   data_path: str,
   project_id: str
):
   """Custom component that takes in a BQ table and
      writes it to GCS.

   Args:
       bq_table: The source biquery table.
       data_path: The gcs location to write the csv.
       project_id: The project ID.
   """
   from google.cloud import bigquery
   import pandas as pd
   ...
```



Defining an AutoMLOps Pipeline

Defining an AutoMLOps pipeline will create a corresponding temporary file within the cache subdirectory:

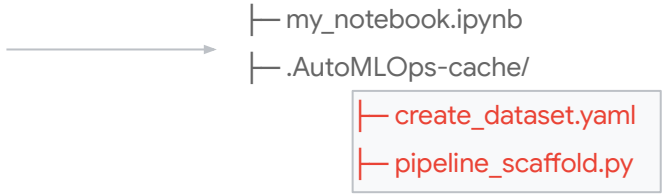
```
@AutoMLOps.pipeline
def pipeline(bq_table: str,
             output_model_directory: str,
             project: str,
             region: str,
            ):

    dataset_task = create_dataset(
        bq_table=bq_table,
        project=project)

    model_task = train_model(
        output_model_directory=output_model_directory,
        dataset=dataset_task.output)

    deploy_task = deploy_model(
        model=model_task.outputs["model"],
```



Clearing the cache

Calling clear_cache will remove all previously defined components and pipelines within the directory. Use this function if you have components or pipelines that you no longer need:

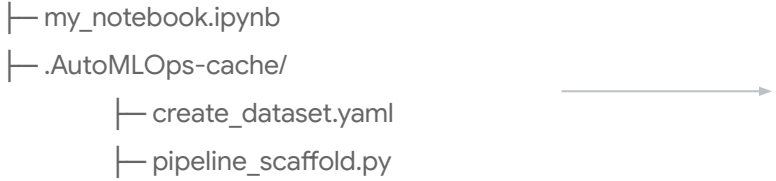
```
AutoMLOps.clear_cache()
```

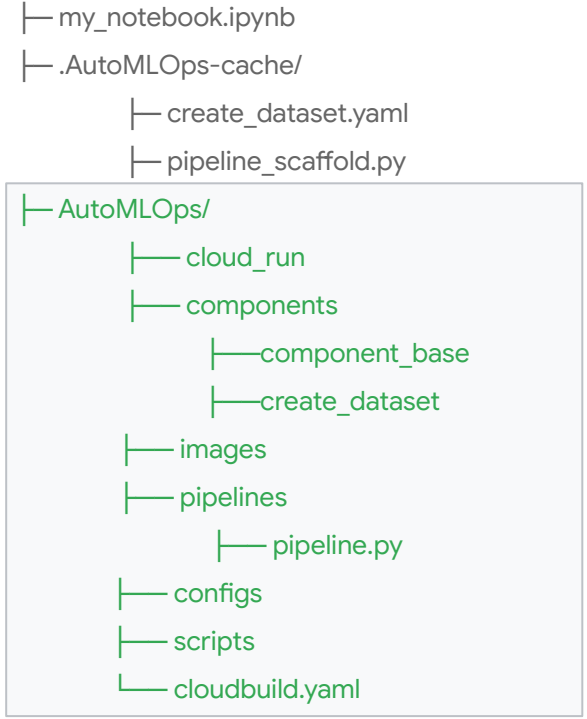


Running AutoMLOps

When AutoMLOps.generate() or AutoMLOps.go() is called, these cached component and pipeline files are “consumed” and turned into the production ready pipeline codebase:

```
AutoMLOps.generate(...)
```





Cloud Resources

When AutoMLOps.go() is run, the following resources are created to run and maintain the MLOps pipeline:

1. AutoMLOps codebase
2. Artifact Registry
3. GS Bucket
4. Pipeline Runner Service Account
5. Cloud Source Repository (turns the notebooks working directory into a CSR)
6. Cloud Build Trigger
7. Cloud Runner Service
8. Cloud Scheduler
9. Cloud Tasks queue

APIs

When AutoMLOps.go() is run, the following APIs are enabled:

1. cloudresourcemanager.googleapis.com
2. aiplatform.googleapis.com
3. artifactregistry.googleapis.com
4. cloudbuild.googleapis.com
5. cloudscheduler.googleapis.com
6. cloudtasks.googleapis.com
7. compute.googleapis.com
8. iam.googleapis.com
9. iamcredentials.googleapis.com
10. ml.googleapis.com
11. run.googleapis.com
12. storage.googleapis.com
13. sourcerepo.googleapis.com

IAM Access

When AutoMLOps.go() is run, the following IAM access roles are updated:

1. **Pipeline Runner Service Account** (created if it does exist, defaults to: *vertex-pipelines@<PROJECT_ID>.iam.gserviceaccount.com*).

   Roles added:

   - roles/aiplatform.user
   - roles/artifactregistry.reader
   - roles/bigquery.user
   - roles/bigquery.dataEditor
   - roles/iam.serviceAccountUser
   - roles/storage.admin
   - roles/run.admin

2. **Cloudbuild Default Service Account** (*<PROJECT_NUMBER>@cloudbuild.gserviceaccount.com*).

   Roles added:

   - roles/run.admin
   - roles/iam.serviceAccountUser
   - roles/cloudtasks.enqueuer
   - roles/cloudscheduler.admin

Package Dependencies

When using AutoMLOps, the following package versions are used:

1. docopt==0.6.2,
2. docstring-parser==0.15,
3. pipreqs==0.4.11,
4. PyYAML==6.0.1,
5. yarg==0.1.9