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Beyond model development, training and deployment - Deep Dive on Amazon SageMaker Model Monitoring

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Agenda

- What is Amazon SageMaker?
- Why do we need model monitoring? Why is it important?
- What is Amazon SageMaker Model Monitor and how it works?
- Types of model monitoring
- Deep Dive on Data Quality Monitoring
- Demo - Data Quality Monitoring
- How to get started with Amazon SageMaker Model Monitoring?

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What is Amazon SageMaker?

Amazon SageMaker Studio

Access ML data
Connect to many data sources such as Amazon S3, Apache Spark, Amazon Redshift, CSV files, and more

Prepare data
Transform data to browse data sources, explore metadata, schemas, and write queries in popular languages

Build ML models
Optimized with 150+ popular open-source models and frameworks such as TensorFlow and PyTorch

Train and tune ML model
Correct performance problems in real time

Deploy and monitor results
Create, automate, and manage end-to-end ML workflows to improve model quality

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Model Development Life Cycle

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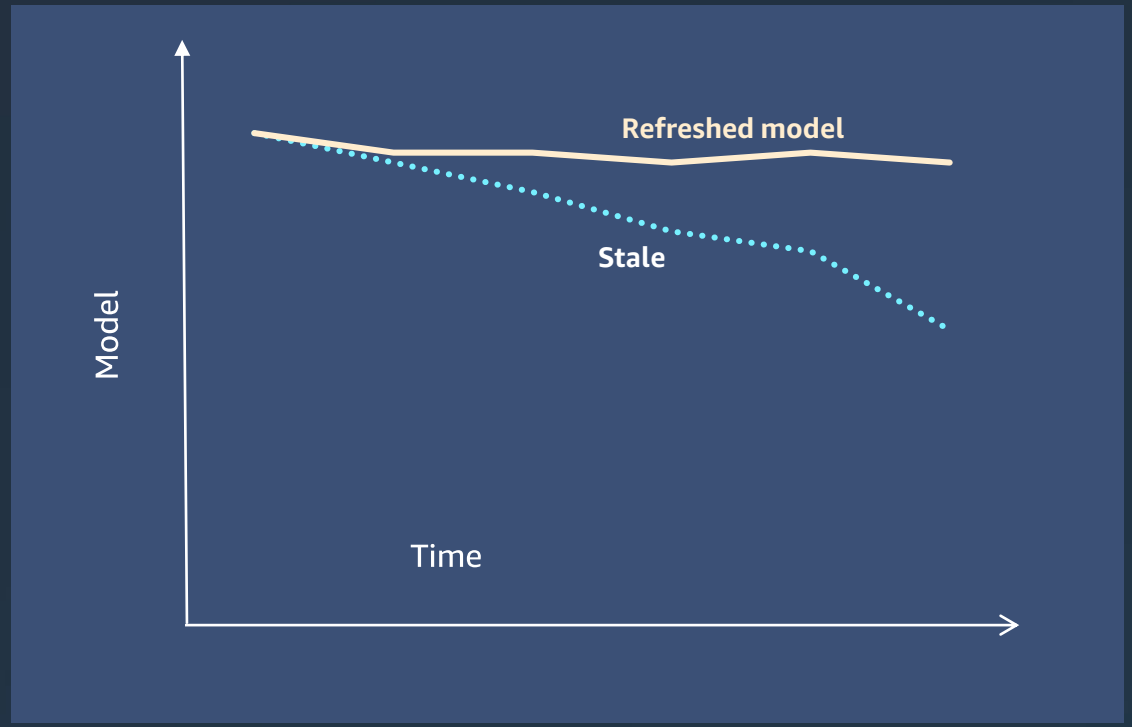
What happens after the model deployment ?

Deploying a model is not the end. You need to continuously monitor models in production and iterate.



- Model accuracy degrade over time
- Bias/change in feature attributions
- Concept drift due to divergence of data

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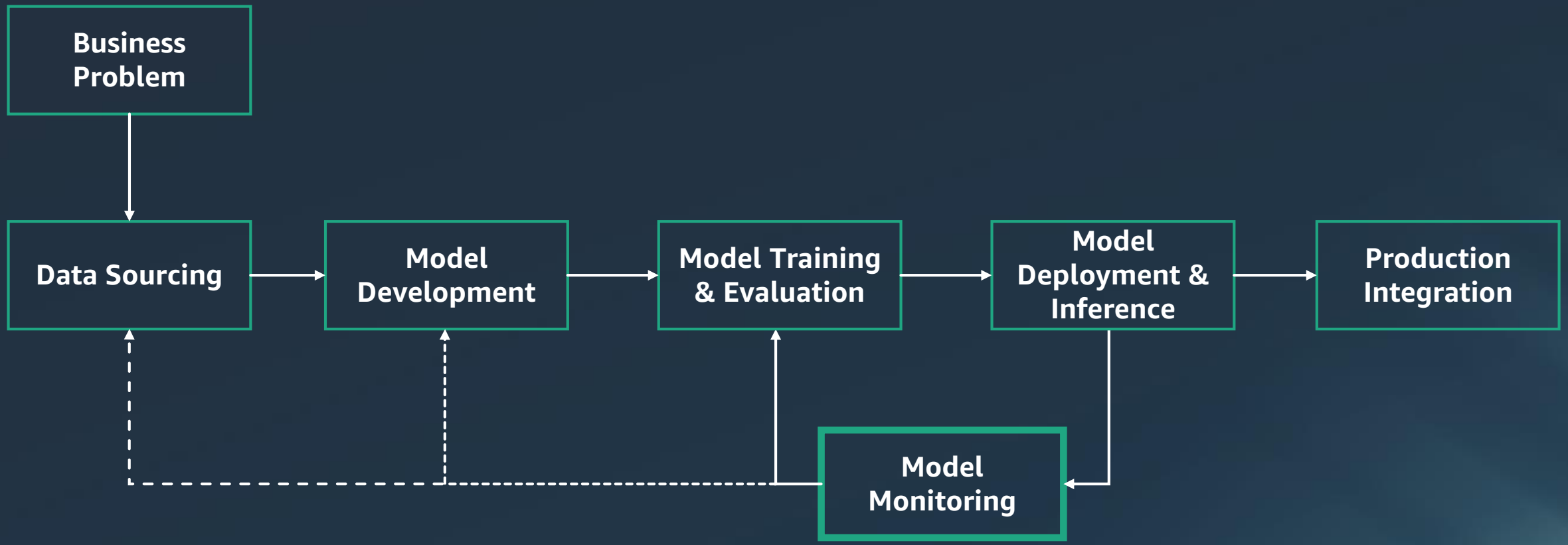
Model Development Life Cycle



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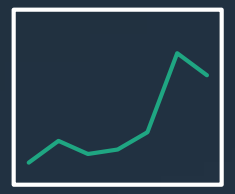
Amazon SageMaker Model Monitor

Automatic data collection

Data collected from endpoints is stored in Amazon S3 Buckets



Continuous monitoring

Define a monitoring schedule and detect changes in quality against a pre-defined baseline

Flexible monitoring Rules

Use built-in rules to detect drift or write your own rules for custom analysis

Visual data analysis

See monitoring results, data statistics, and violation reports in Amazon SageMaker Studio; Analyze in Notebooks

Amazon CloudWatch integration

Metrics emitted to Amazon CloudWatch make it easy to alarm and automate corrective actions

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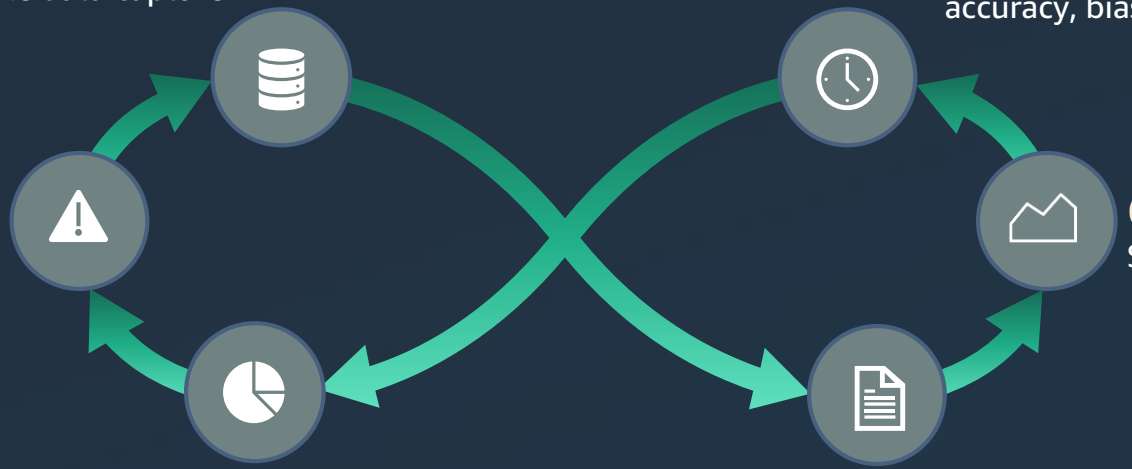
How does Amazon SageMaker Model Monitor work?



Deploy trained model
Enable data capture

Schedule monitoring jobs
Detect and monitor data quality, model accuracy, bias, and explainability drift

CloudWatch Alerts
Retrain models / Update data

Generate baseline
Statistics and constraints

View drift monitoring results
Reports in Amazon S3, visualize metrics in Amazon SageMaker Studio, analyze in Amazon Notebooks

Collect ground truth
Merge with predictions

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Monitoring types supported

Model Monitor supports monitoring and detection of following types of drift

Data Quality

Detect divergence in data

- Real time data capture from endpoints
- Define Baseline
- Pre-built container and custom analysis
- Type, Num Present, Num Missing
- Mean, Sum, Std Dev

Model Quality

Detect quality degradation over time

- Merge predictions with GroundTruth
- Compare predictions to GroundTruth
- Generate reports and violations
- MAE, RMSE, F1

Model Bias

Track model balance

- Overfitting
- Underfitting
- Class Imbalance
- DPL
- KL Divergence
- LP-Norm

Model Explainability

Feature attribution

- How much each feature contributed to predictions
- Shapley Values

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Data Quality Monitoring

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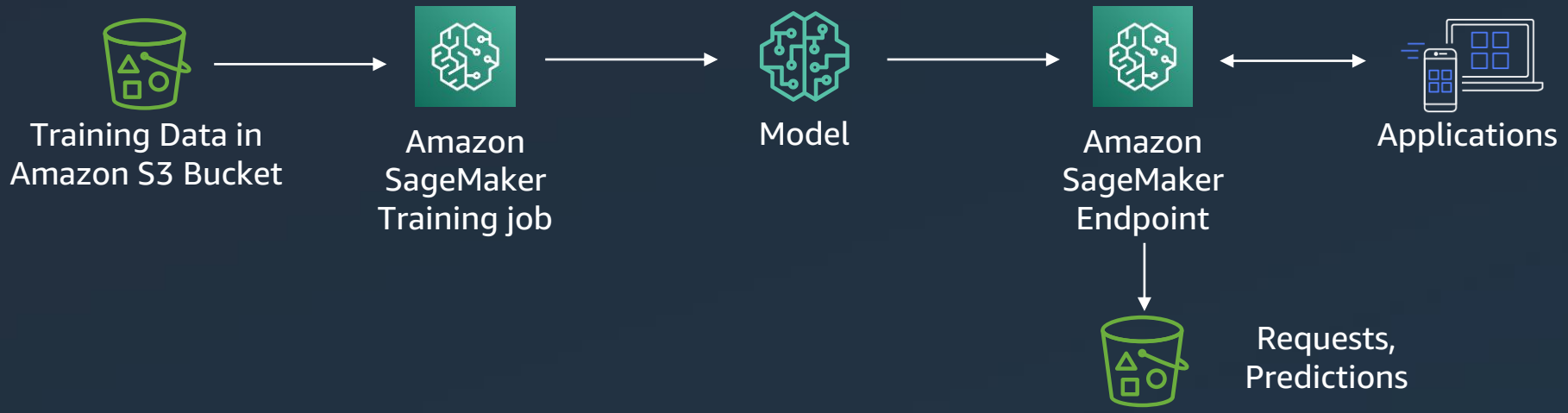
Step 1 - Deploy Model and Configure Data Capture



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Step 1 - Deploy Model and Configure Data Capture

```
from sagemaker.model_monitor import DataCaptureConfig

endpoint_name = 'DEMO-xgb-churn-pred-model-monitor-' + strftime("%Y-%m-%d-%H-%M-
%S", gmtime())

data_capture_config = DataCaptureConfig(
                        enable_capture=True,
                        sampling_percentage=100,
                        destination_s3_uri=s3_capture_upload_path)

predictor = model.deploy(initial_instance_count=1,
                instance_type='ml.m4.xlarge',
                endpoint_name=endpoint_name,
                data_capture_config=data_capture_config)
```

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Step 1 - Data Capture – Input and Output


```
{
  "captureData": {
    "endpointInput": {
      "observedContentType": "text/csv",
      "mode": "INPUT",
      "data":
"92,0,176.3,85,93.4,125,207.2,107,9.6,1,2,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,1,0",
      "encoding": "CSV"
    },
    "endpointOutput": {
      "observedContentType": "text/csv; charset=utf-8",
      "mode": "OUTPUT",
      "data": "0.039806101471185684",
      "encoding": "CSV"
    }
  },
  "eventMetadata": {
    "eventId": "81f77a8a-314e-4c95-8908-189d5c9656e0",
    "inferenceTime": "2022-08-11T13:18:40Z"
  },
  "eventVersion": "0"
}
```


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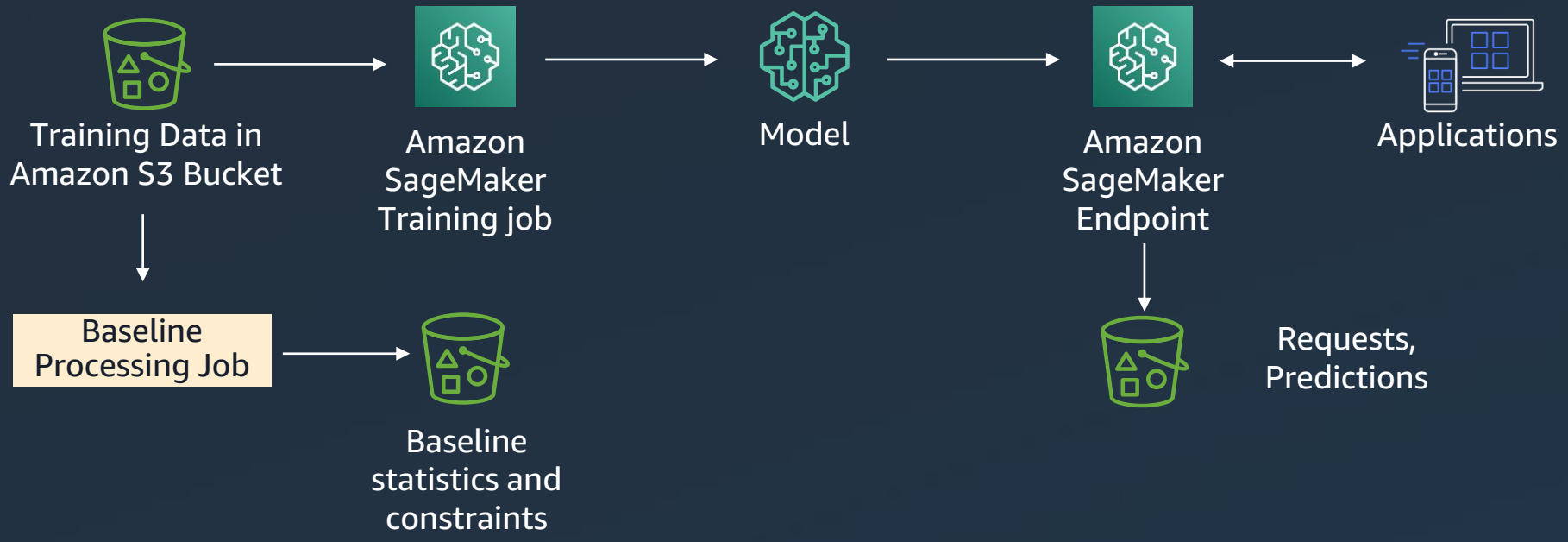
Step 2 – Create Baseline



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Step 2 – Create Baseline

A *constraints.json* file is used to express the constraints that a dataset must satisfy.


```
{
    "name" : "Night Calls",
    "inferred_type" : "Integral",
    "completeness" : 1.0,
    "num_constraints" : {
      "is_non_negative" : true
    }
  }
```


The schema defined in the *statistics.json* file specifies the statistical parameters to be calculated for the baseline and data that is captured.


```
{
    "name" : "Night Calls",
    "inferred_type" : "Integral",
    "numerical_statistics" : {
      "common" : {
        "num_present" : 2333,
        "num_missing" : 0
      },
      "mean" : 100.22717531075868,
      "sum" : 233830.0,
      "std_dev" : 19.28202933863294,
      "min" : 42.0,
      "max" : 175.0,
      "distribution" : { …
```


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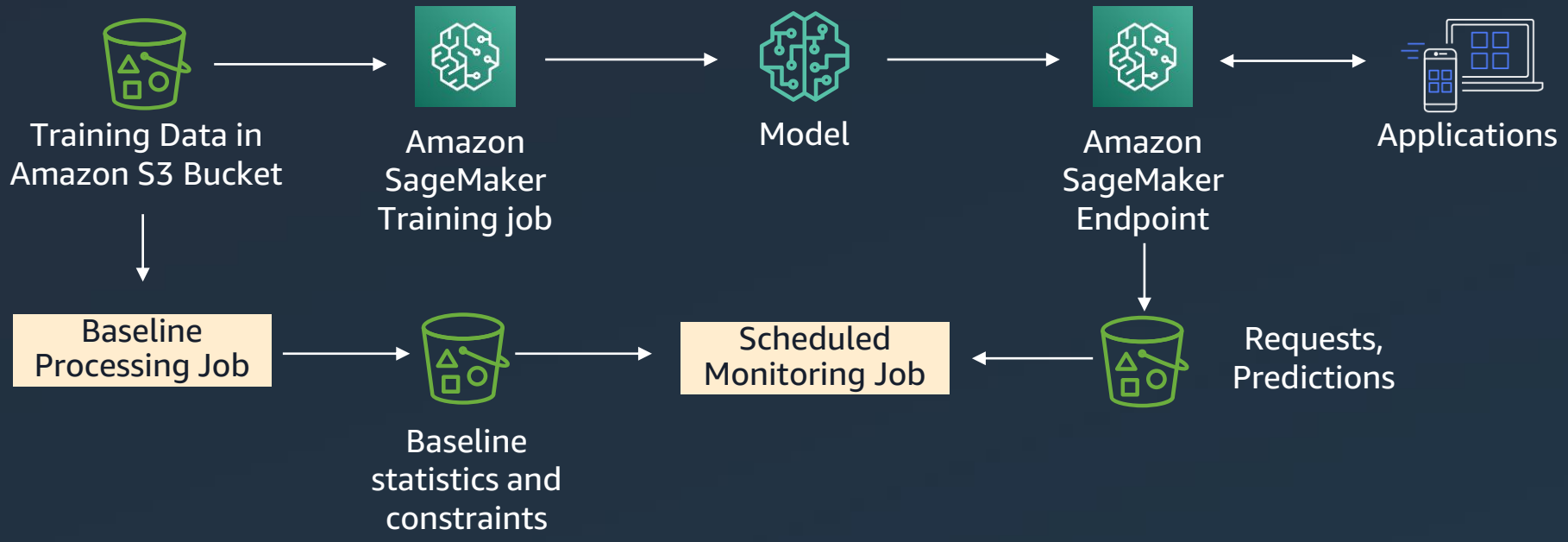
Step 3 – Schedule Monitoring Job



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Step 3 – Schedule Monitoring Job

1. Amazon Model Monitor runs a **ProcessingJob** on your behalf at the schedule you select –i.e. Monitoring Jobs
2. It analyzes the data collected using your choice of analysis container (pre-built or custom)
3. It compares results against the **baseline**
4. You can generate results for each **Monitoring Job**
    - **Violations report** for each job in Amazon S3
    - Statistics report for data collected during the run
    - Emits summary metrics and statistics to Amazon CloudWatch

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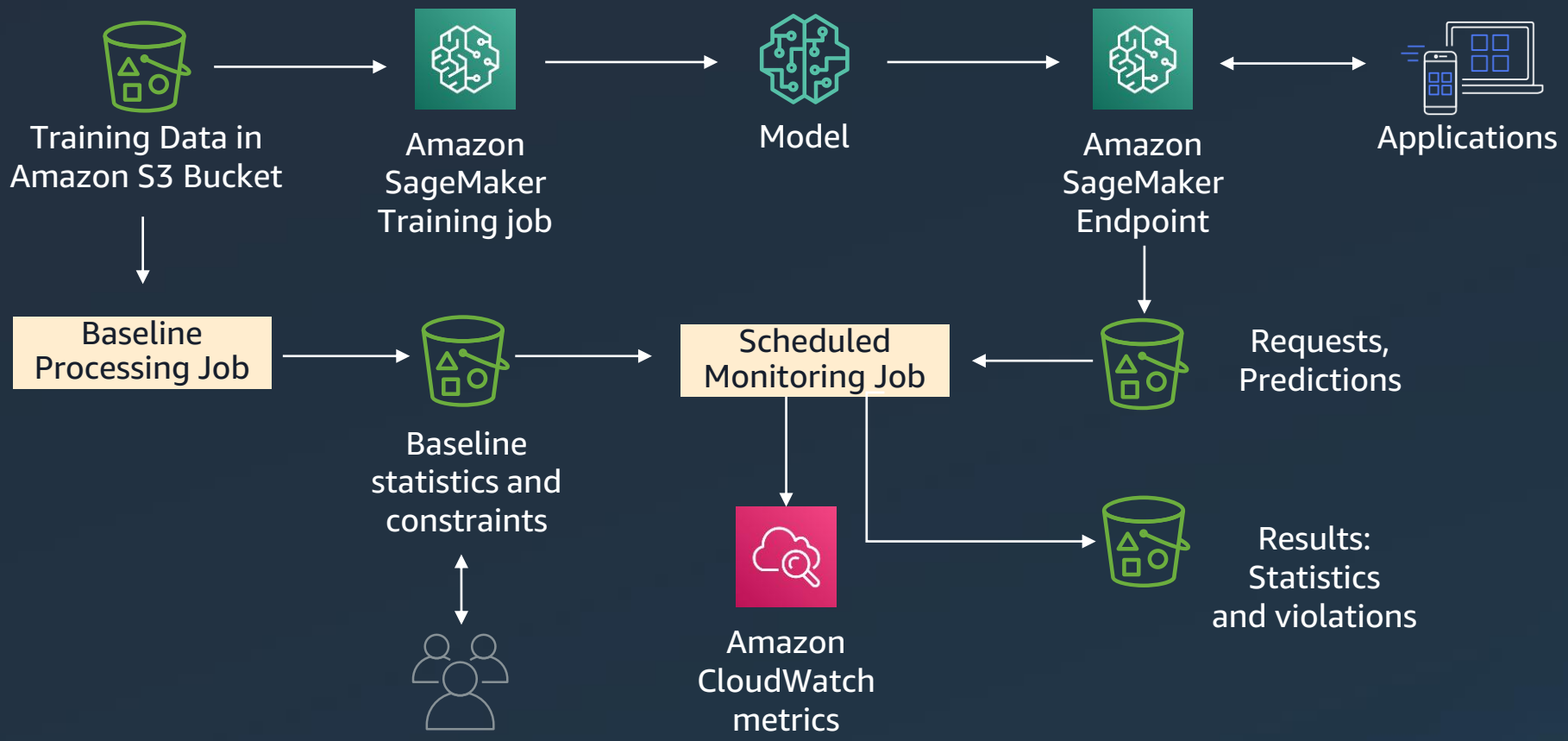
Step 4 – View Monitoring Results



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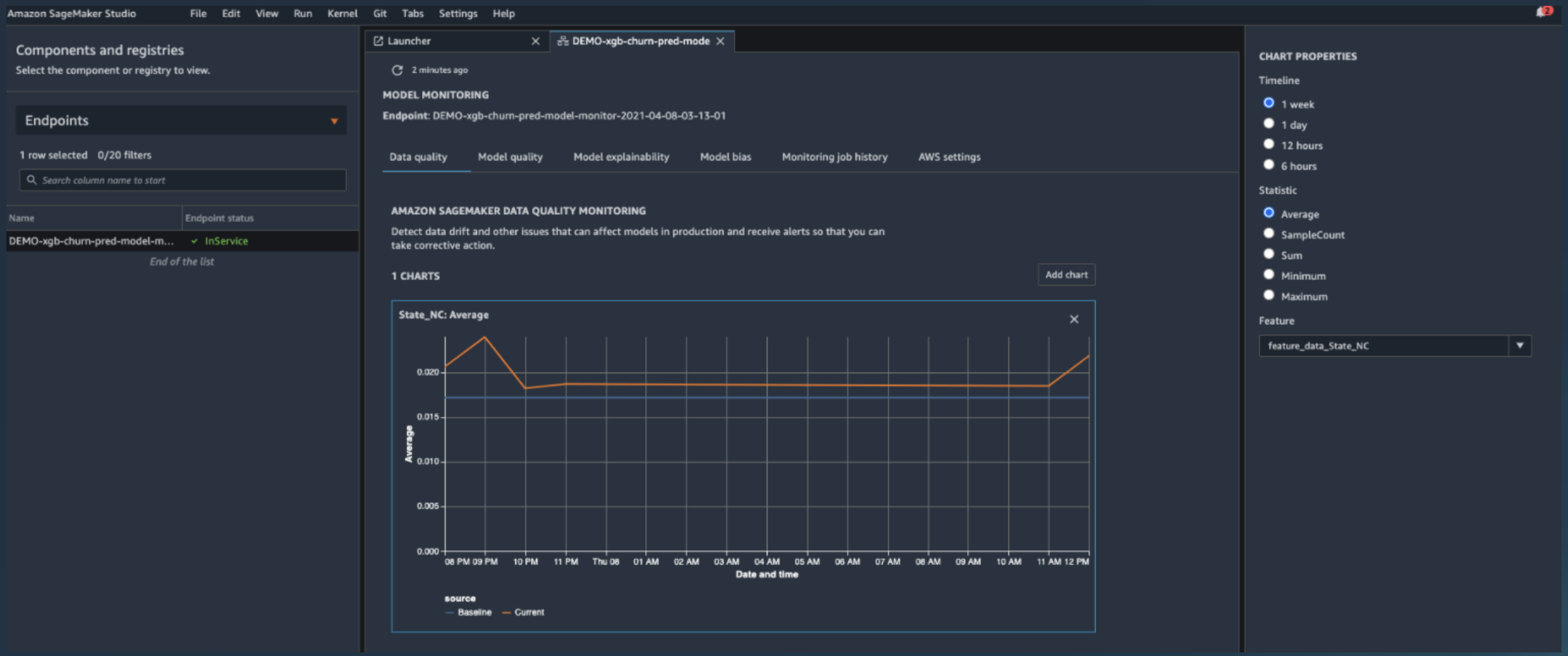
Step 4 – View Monitoring Results



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Step 4 – View Violations

	feature_name	constraint_check_type	description
0	State_MA	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
1	State_AL	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
2	State_AZ	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
3	State_WY	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
4	State_NE	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
5	State_GA	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
6	State_OR	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
7	VMail Plan_no	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
8	VMail Message	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.
9	State_DE	data_type_check	Data type match requirement is not met. Expected data type: Integral, Expected match: 100.0%. Observed: Only 99.6236559139785% of data is Integral.

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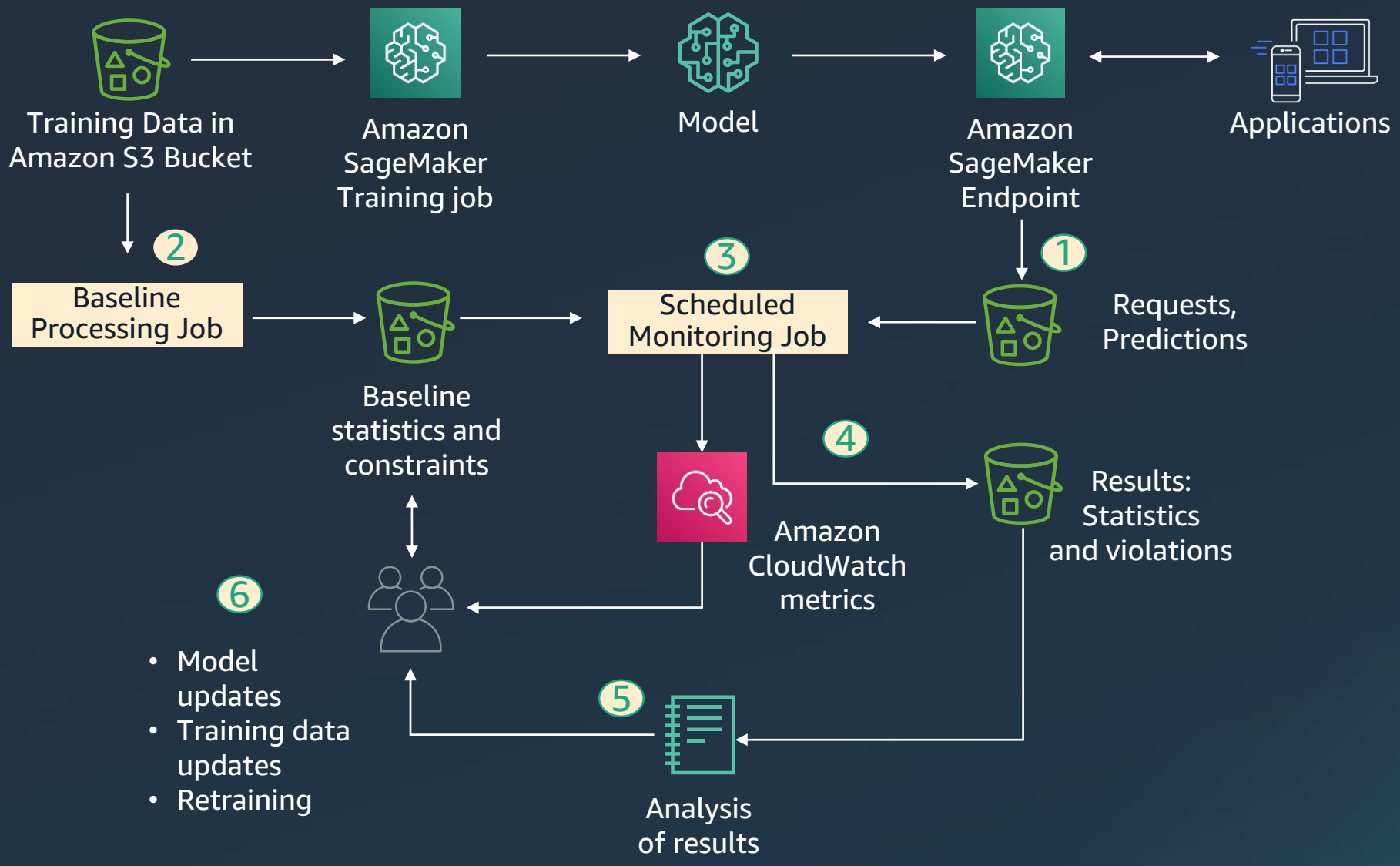
Step 5 – Take corrective actions



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Demo – Data Quality Monitoring

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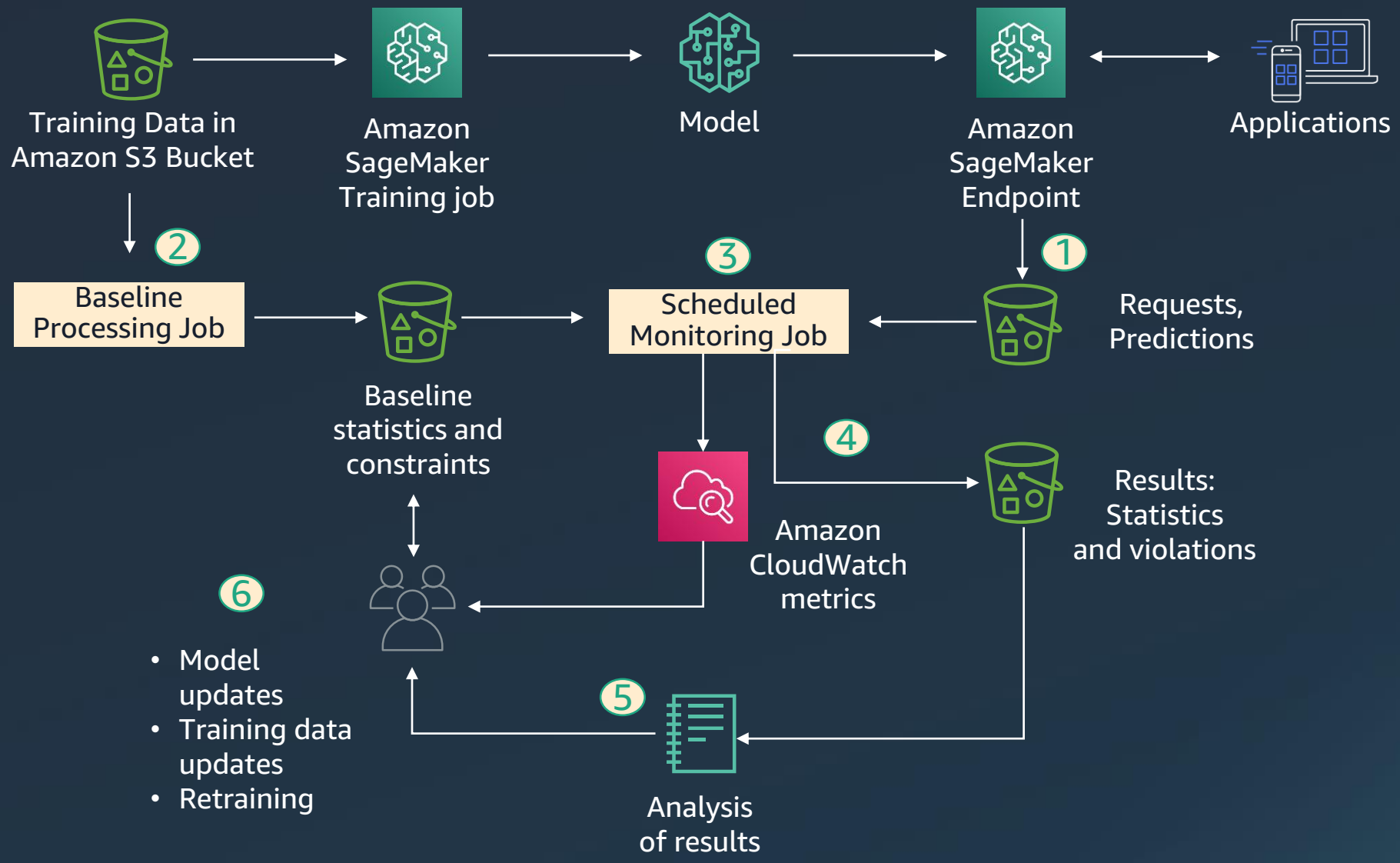
Demo – Data Quality Monitoring



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Recap

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How can you get started?

- Introduction to Amazon SageMaker
- Amazon SageMaker Model Monitor details
- Amazon SageMaker examples (GitHub)
- Amazon SageMaker Model Monitor examples (GitHub)
- Amazon SageMaker Machine Learning tutorials (with hands-on labs)
- Amazon SageMaker pricing
- AWS Free Tier

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