MATLAB EXPO

DevOps with MATLAB: A Predictive Maintenance System for Streaming Data

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He/Him

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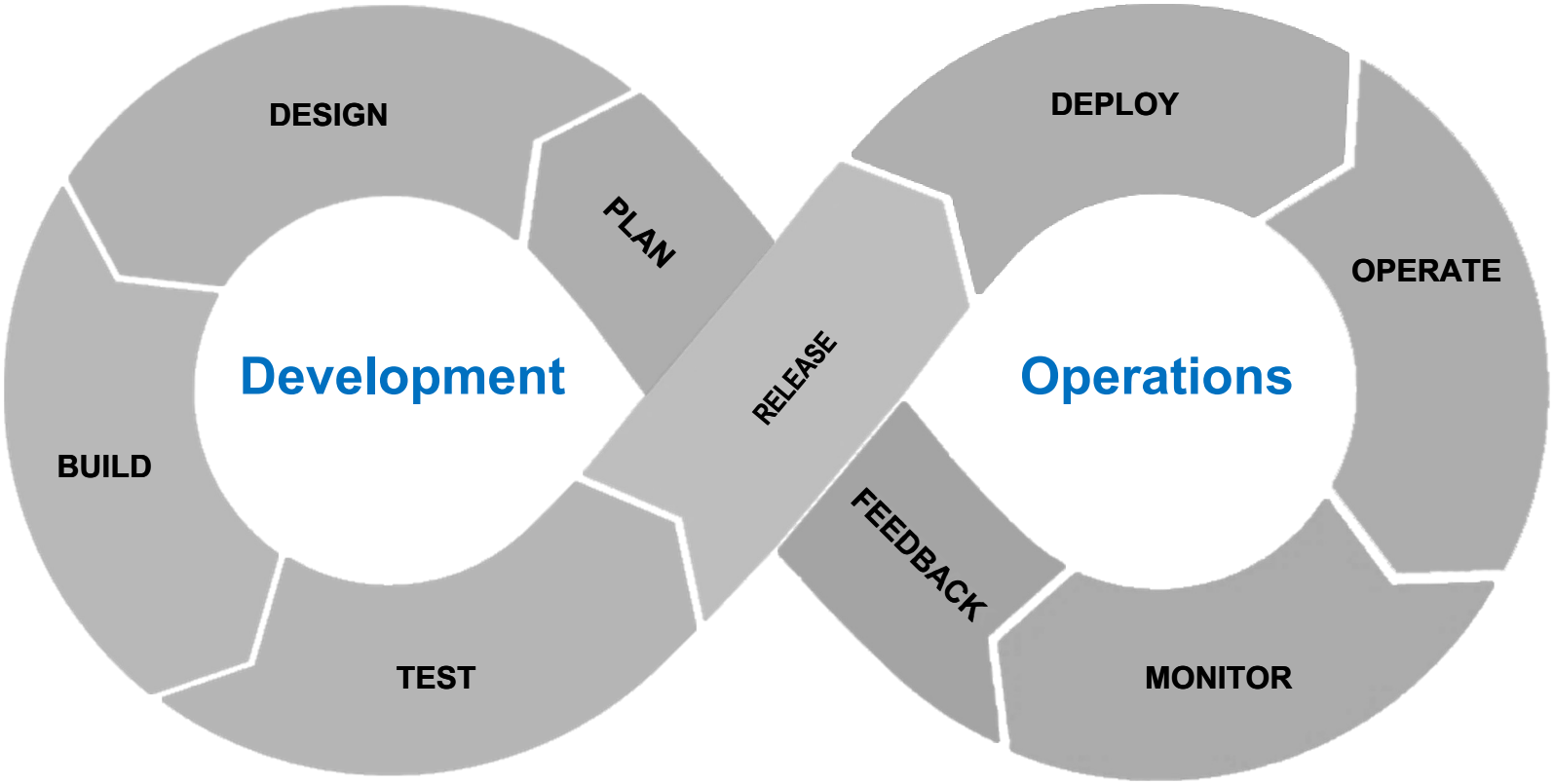
Key Takeaways

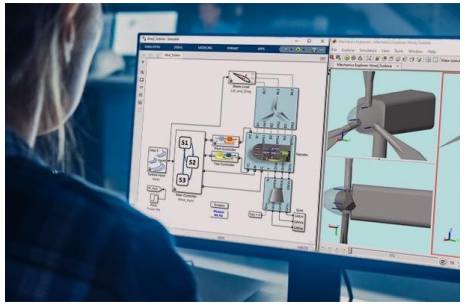
- **Incorporate familiar MATLAB capabilities**, including Predictive Maintenance and Drift Detection, in operations
- **Integrate with production systems** like data sources and dashboards, and translate those integrations from desktop to cloud servers
- **Automatically build, test, package, and deploy MATLAB code and Simulink models** with CI/CD

DevOps: Develop and Operate Production Software



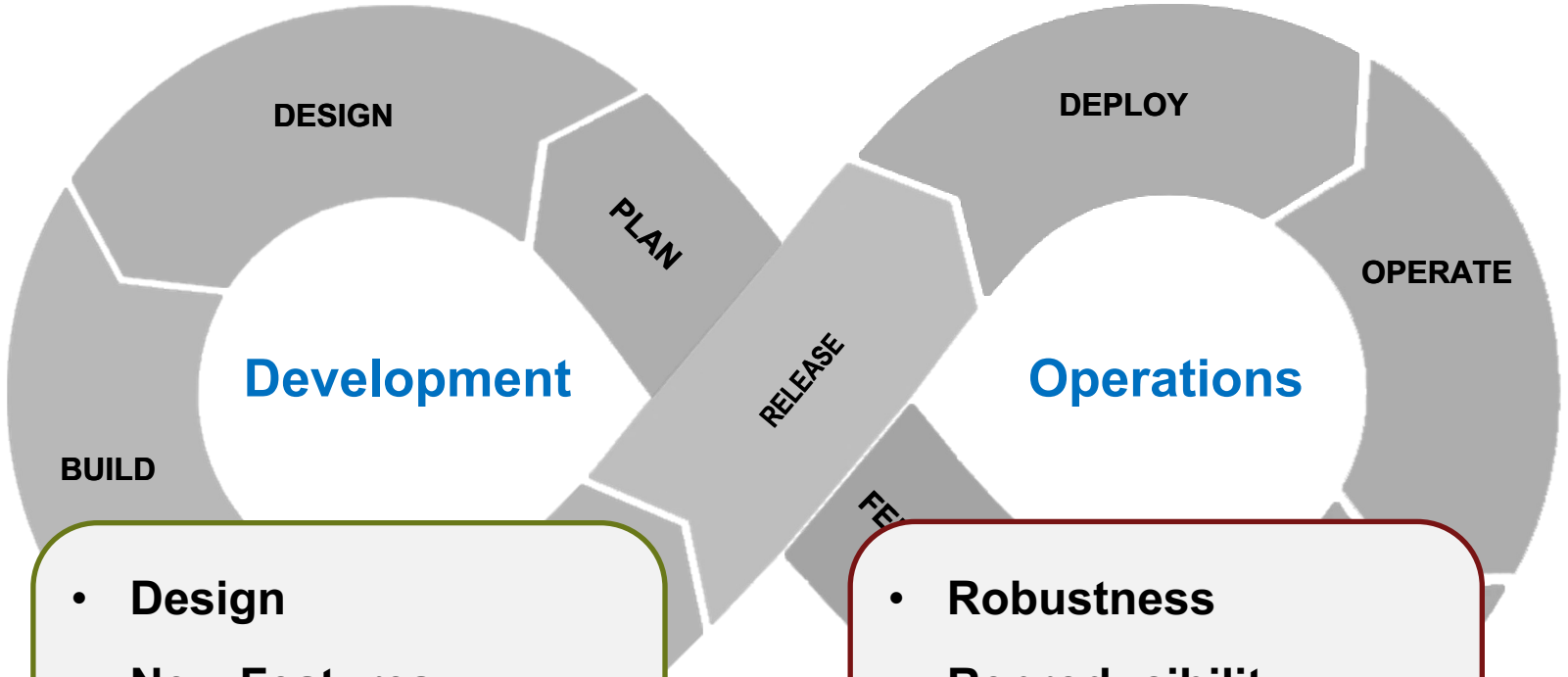
Predictive Maintenance

Financial Modeling



Embedded Controls

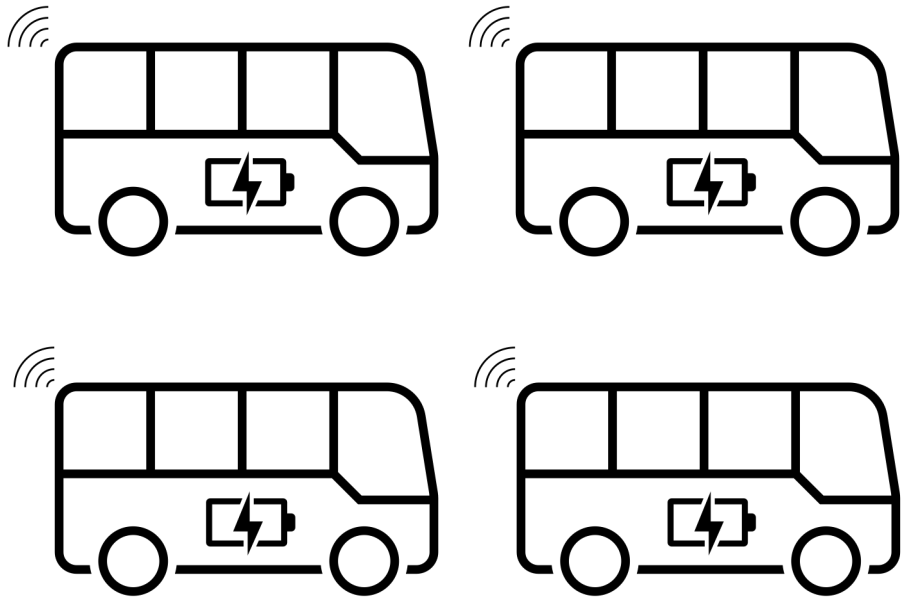
Not necessarily a conflict of interests, but certainly different interests



- Design
- New Features
- Performance
- Testing

- Robustness
- Reproducibility
- Scalability
- Monitoring

Example:
Predicting Battery State-of-Health



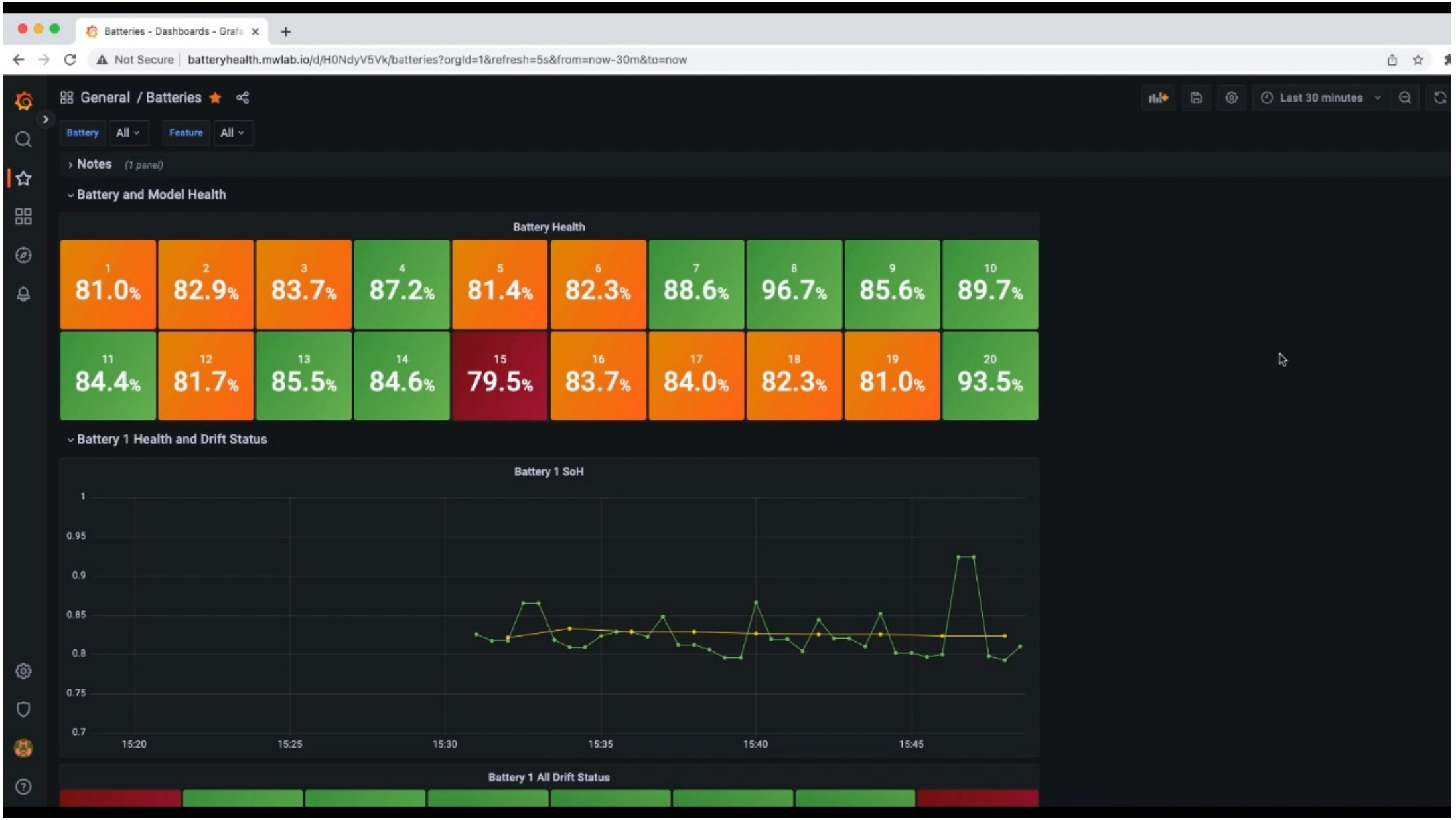
- Fleet of electric buses
- Maintenance is expensive. **Could we do a better job predicting when batteries need replacing?**
- Started gathering telemetry data on batteries

Variables – observations

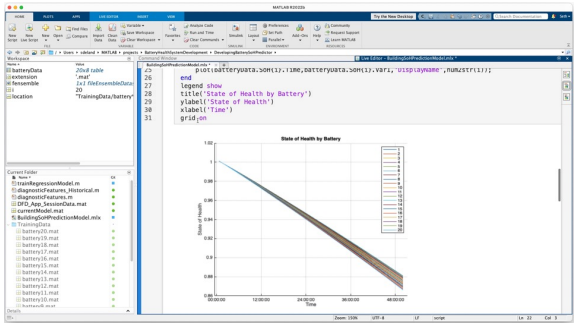
observations

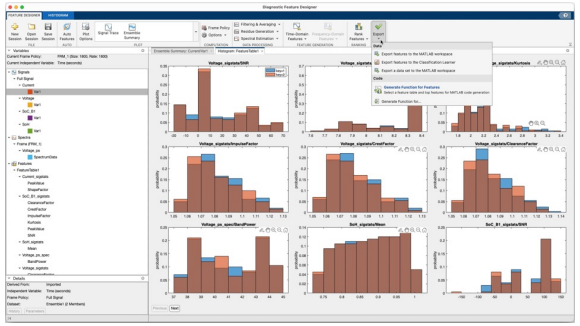
1800x7 timetable

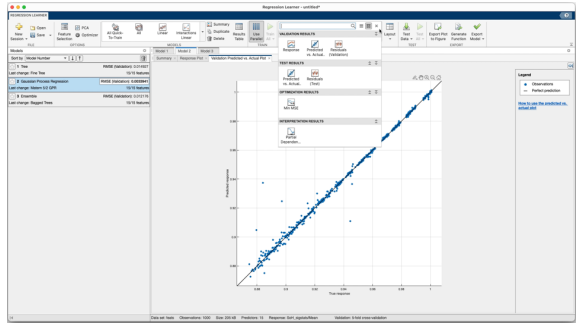
	timestamp	1 Current	2 Voltage	3 Temperature1	4 Temperature2	5 SoC_B1	6 SoC_B2	7 BatteryID
1	01-Nov-2021 00:...	2.6869	7.4436	333.1463	332.7619	0.4995	0.4995	1
2	01-Nov-2021 00:...	2.6872	7.4426	333.1317	332.3924	0.4990	0.4990	1
3	01-Nov-2021 00:...	2.6876	7.4417	333.1073	332.0405	0.4985	0.4985	1
4	01-Nov-2021 00:...	2.6879	7.4408	333.0740	331.7048	0.4980	0.4980	1
5	01-Nov-2021 00:...	2.6882	7.4399	333.0327	331.3844	0.4975	0.4975	1
6	01-Nov-2021 00:...	2.6885	7.4390	332.9843	331.0783	0.4970	0.4970	1
7	01-Nov-2021 00:...	2.6889	7.4381	332.9295	330.7857	0.4965	0.4965	1


Batteries - Dashboards - Grafa
Not Secure
batteryhealth.mwlab.io/d/H0NdyV5Vk/batteries?orgId=1&refresh=5s&from=now-30m&to=now
General / Batteries
Last 30 minutes
Battery
All
Feature
All
Notes (1 panel)
Battery and Model Health
Battery Health
1 81.0%
2 82.9%
3 83.7%
4 87.2%
5 81.4%
6 82.3%
7 88.6%
8 96.7%
9 85.6%
10 89.7%
11 84.4%
12 81.7%
13 85.5%
14 84.6%
15 79.5%
16 83.7%
17 84.0%
18 82.3%
19 81.0%
20 93.5%
Battery 1 Health and Drift Status
Battery 1 SoH
1
0.95
0.9
0.85
0.8
0.75
0.7
15:20
15:25
15:30
15:35
15:40
15:45
Battery 1 All Drift Status

Create a SoH prediction function using domain-specific tools for engineering data and predictive maintenance

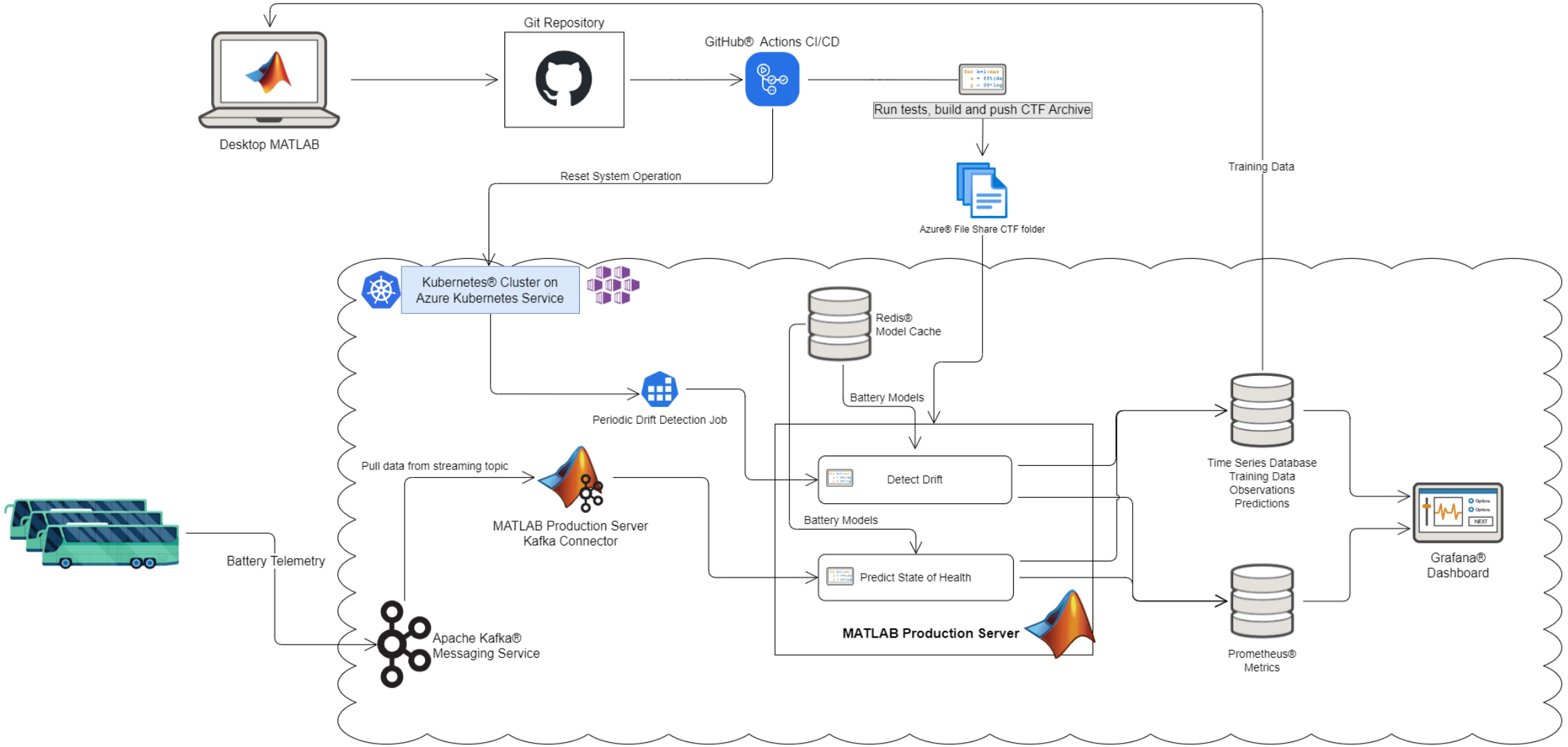






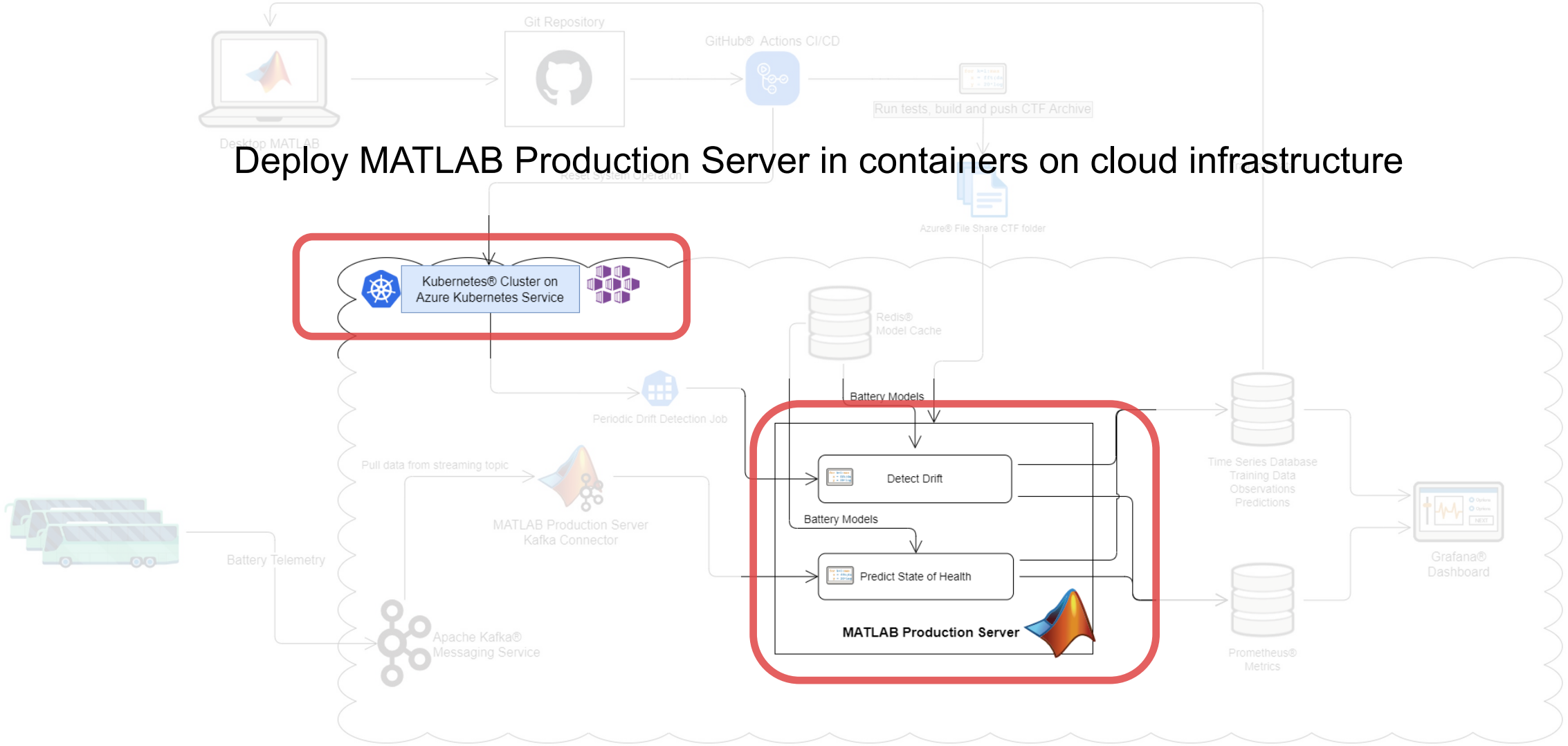
Data Exploration → **Feature Extraction** → **Machine Learning**

A scalable production system running on the cloud, using industry standard tools



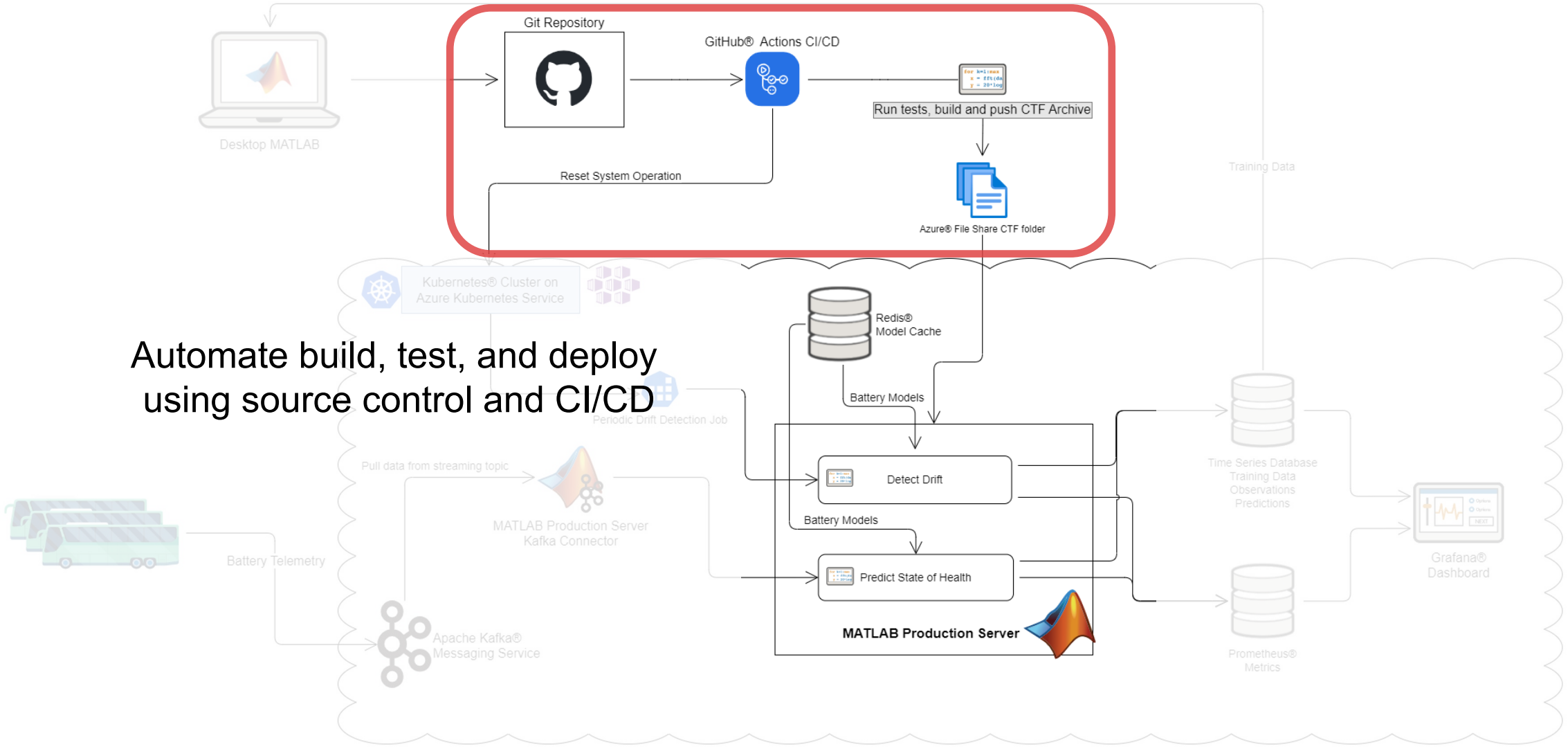
A scalable production system running on the cloud, using industry standard tools

Deploy MATLAB Production Server in containers on cloud infrastructure



A scalable production system running on the cloud, using industry standard tools

Automate build, test, and deploy using source control and CI/CD



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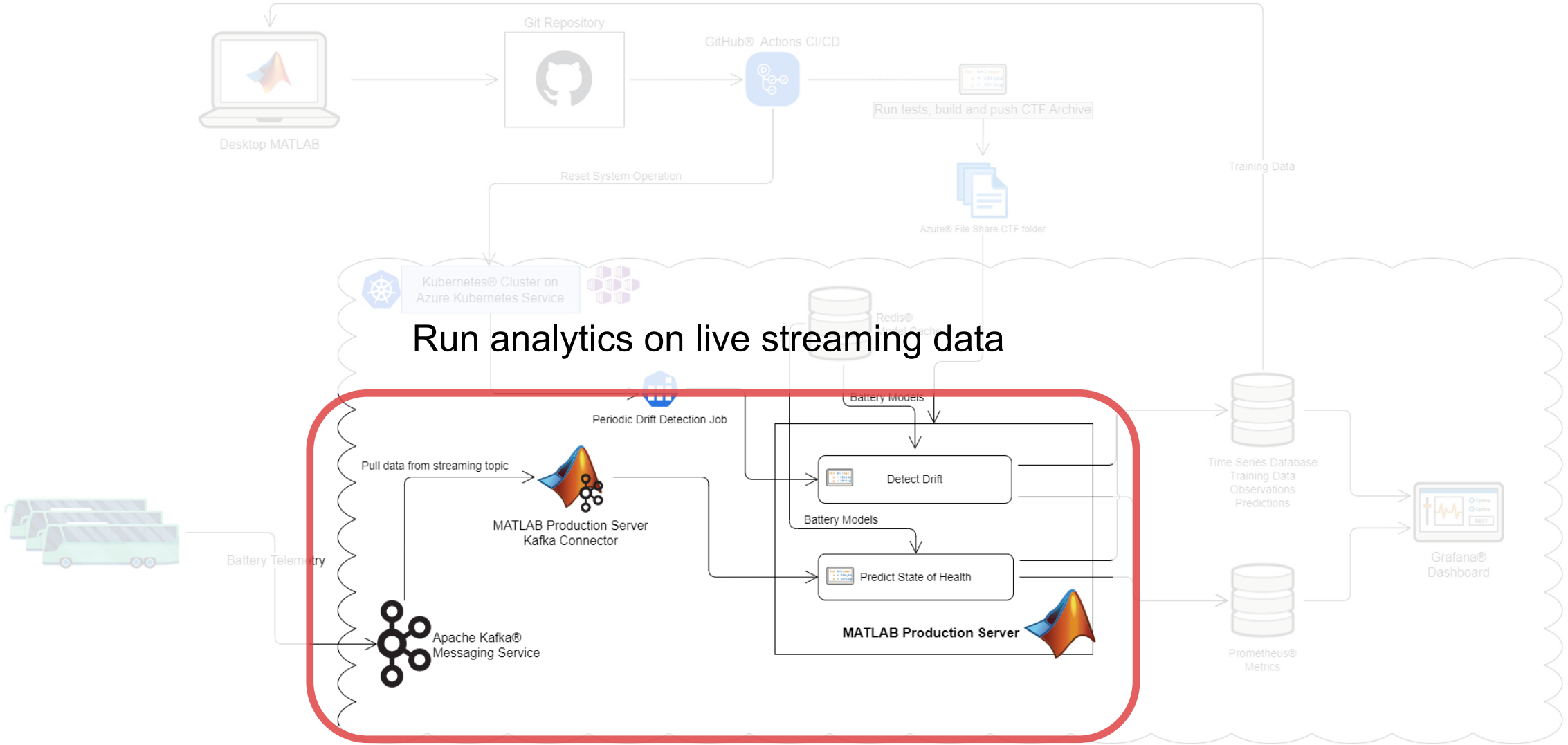

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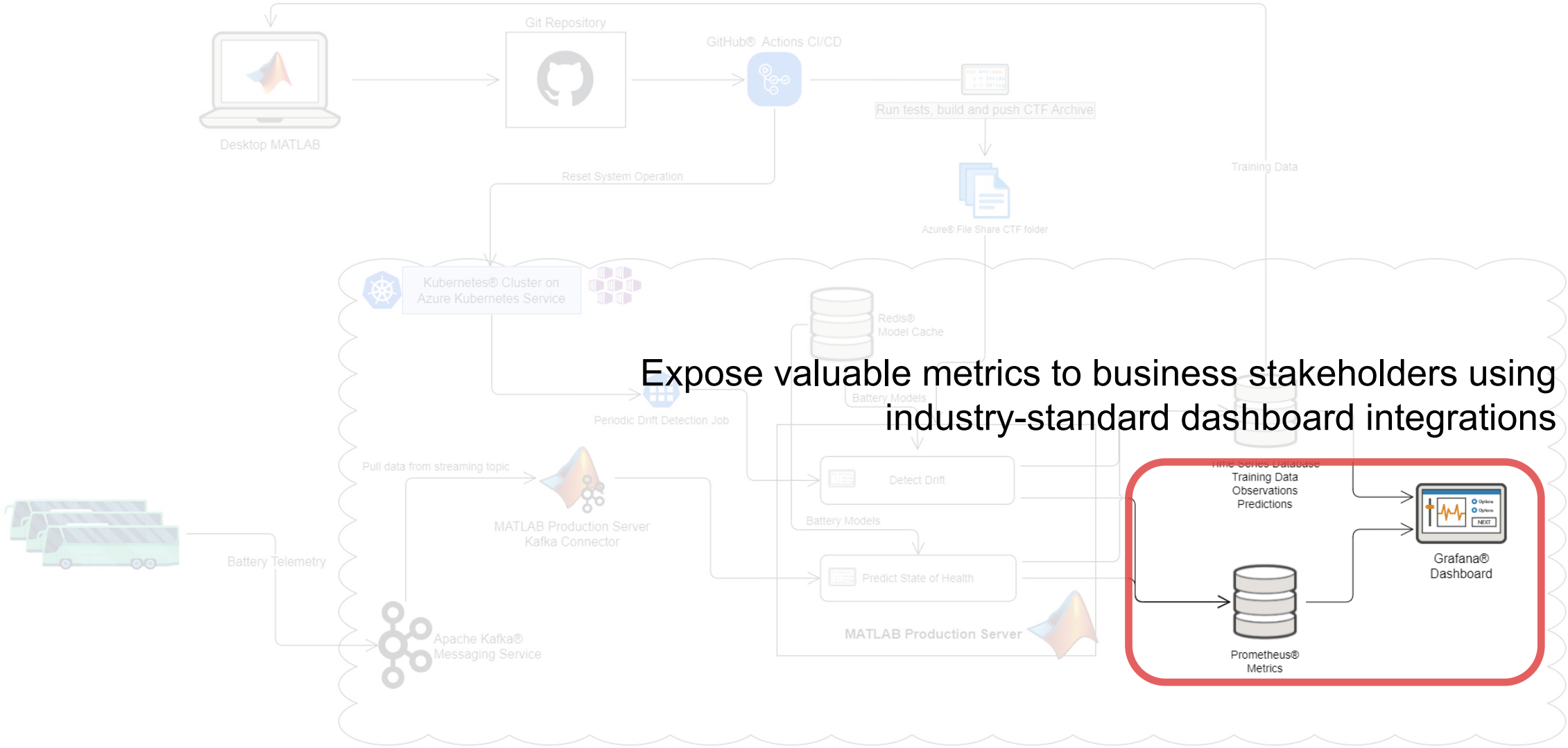
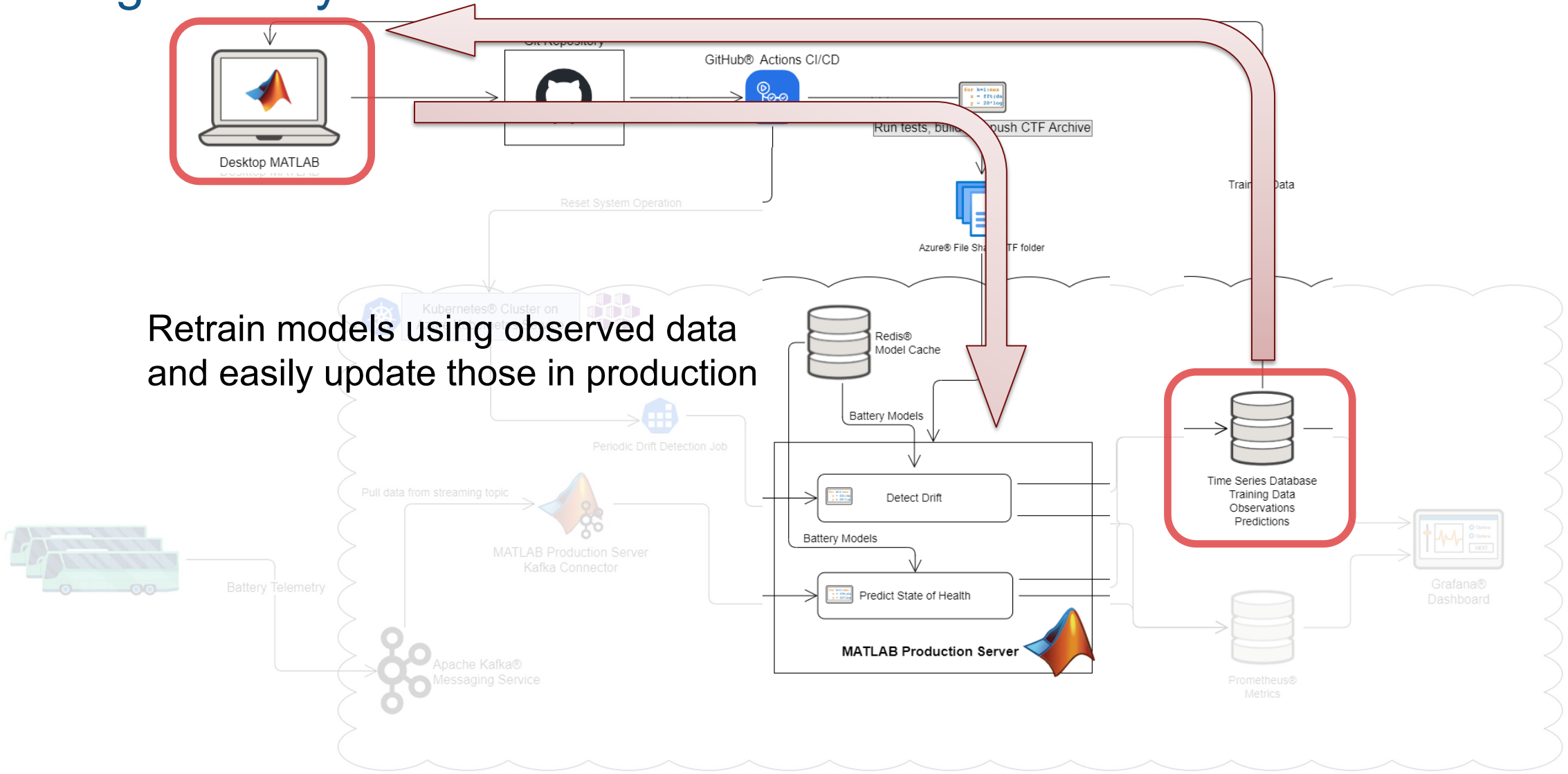


Expose valuable metrics to business stakeholders using industry-standard dashboard integrations

A scalable production system running on the cloud, using industry standard tools

Retrain models using observed data and easily update those in production



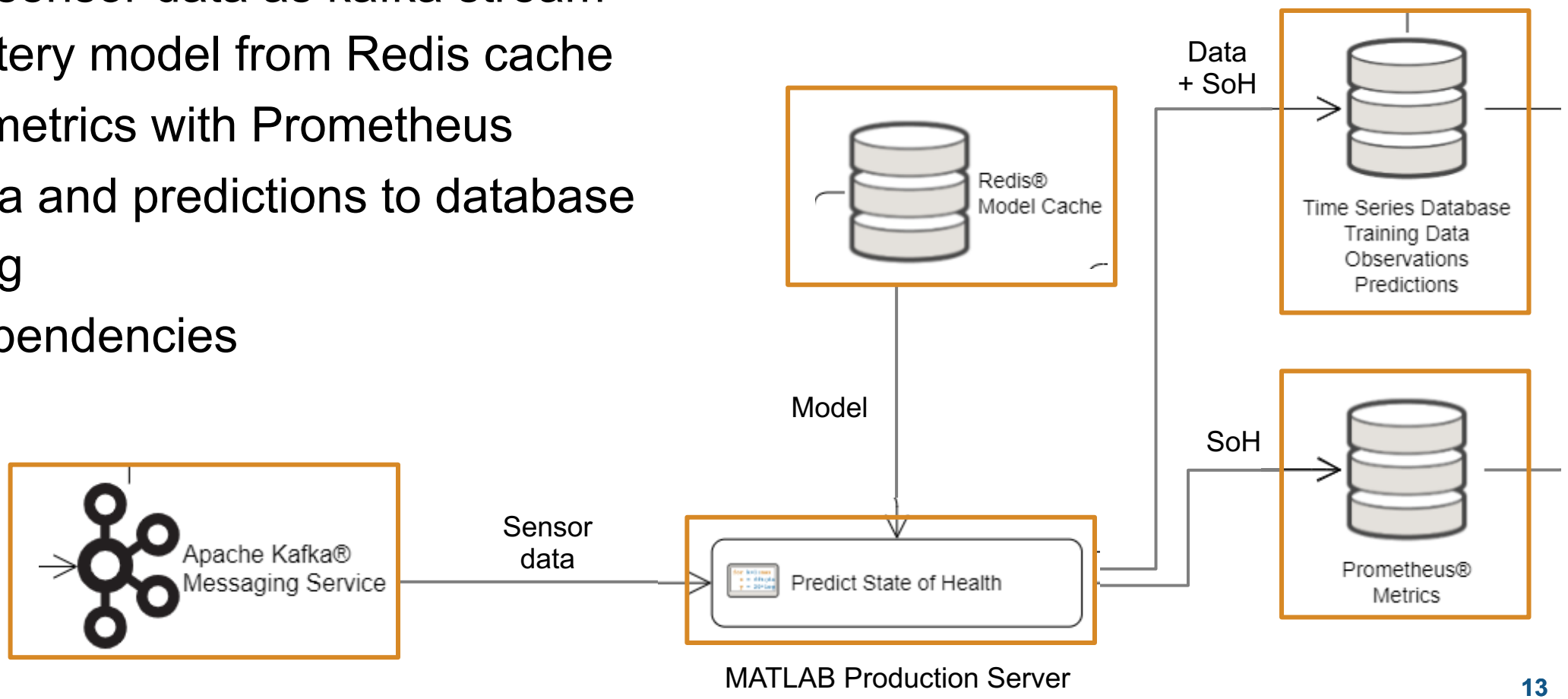
State of health algorithm in production

Production System

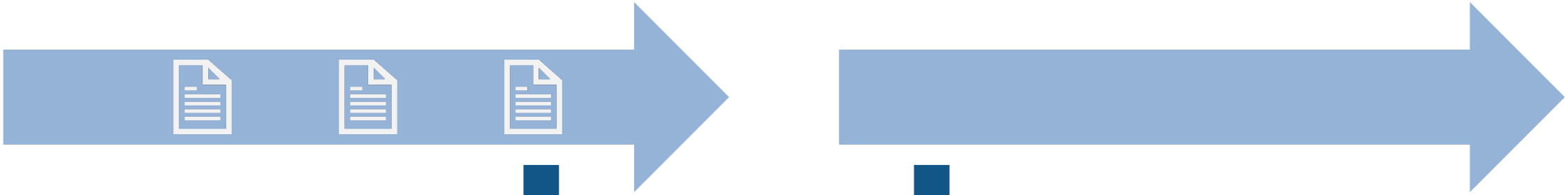
- Receive sensor data as kafka stream
- Load battery model from Redis cache
- Expose metrics with Prometheus
- Save data and predictions to database

Local testing

- Mock dependencies

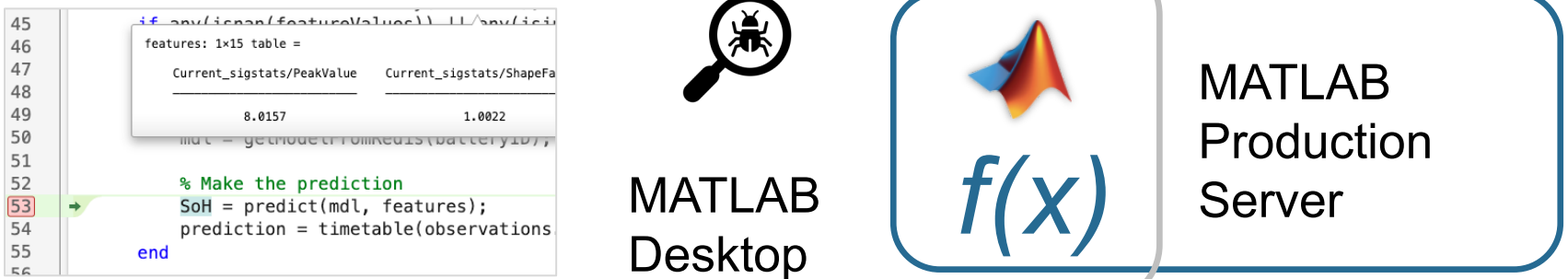


Write SoH prediction function to use kafka streams



Simulate streams with
- `inMemoryStream`
- `testStream`

Use production Kafka streams with `kafkaStream`



Debug locally, then deploy the same MATLAB code to production.

Automatically build, test, package, and deploy MATLAB code

esteinerMW / Battery-Health-Estimation-Streaming-Demo Private

forked from mathworks/Battery-Health-Estimation-Streaming-Demo

Watch 0 Fork 2 Star 1

Code Pull requests Actions Projects Wiki

Build and upload deployable archive (CTF) to MATLAB Production Server

update battery dashboard #19

Summary

Jobs

build

Reset Demo Operations

Run details

Usage

Workflow file

build

succeeded 12 hours ago in 3m

Set up job

Run actions/checkout@v3 3s

Setup MATLAB Support Packages 0s

Setup MATLAB

Run MATLAB buildtool

1 ▶ Run matlab-actions/run-build@v1

8 ▶ Generate script

10 ▶ Run command

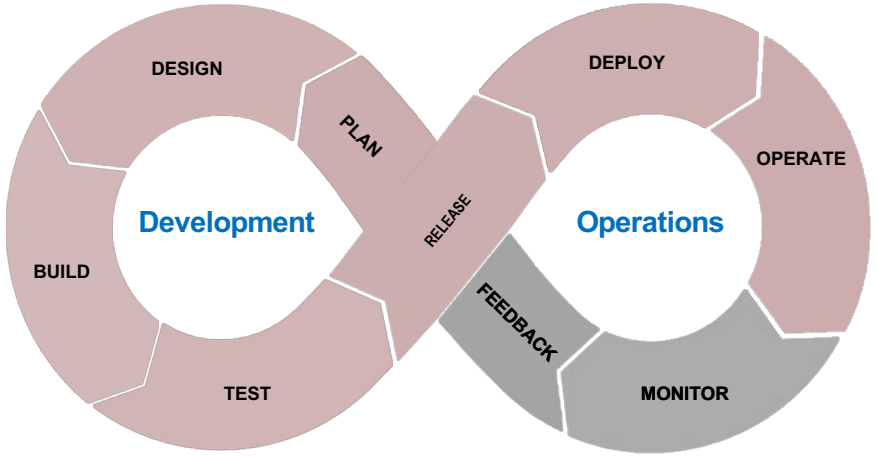
Azure login

Azure CLI script - upload CTF to az file-share

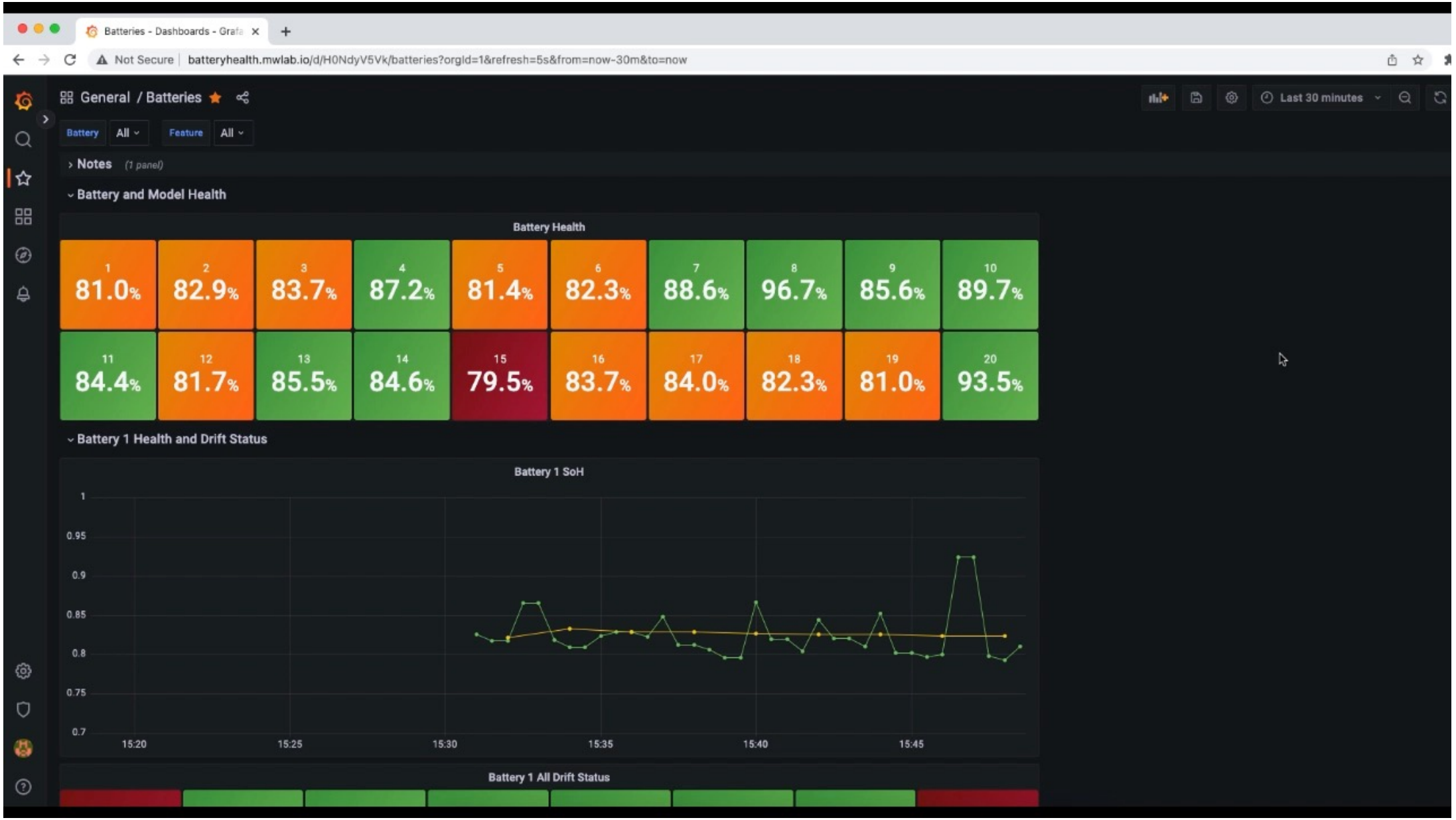
Post Run actions/checkout@v3

Complete job

```
- name: Run MATLAB buildtool
uses: matlab-actions/run-
build@v1
with:
tasks: packageDriftDetection
packageSoHPrediction
```




```
function plan = buildfile
plan = buildplan(localfunctions);
plan("packageDriftDetection").Dependen
cies = "test";
plan("packageSoHPrediction").Dependenc
ies = "test";
plan("test").Dependencies =
"validate";
```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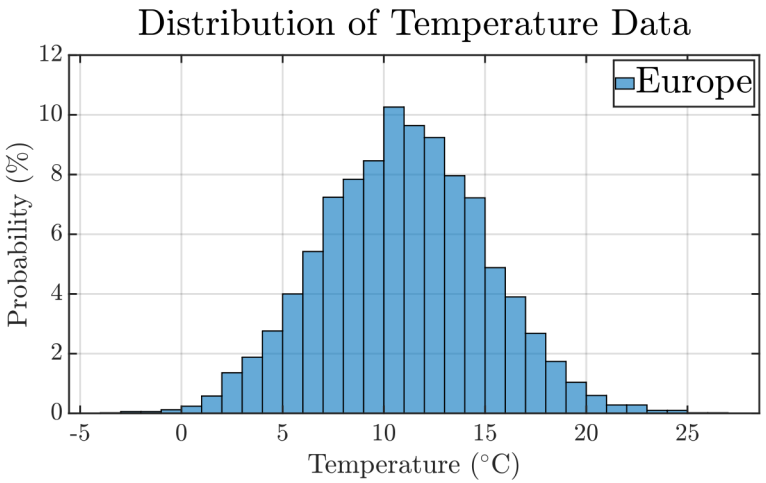
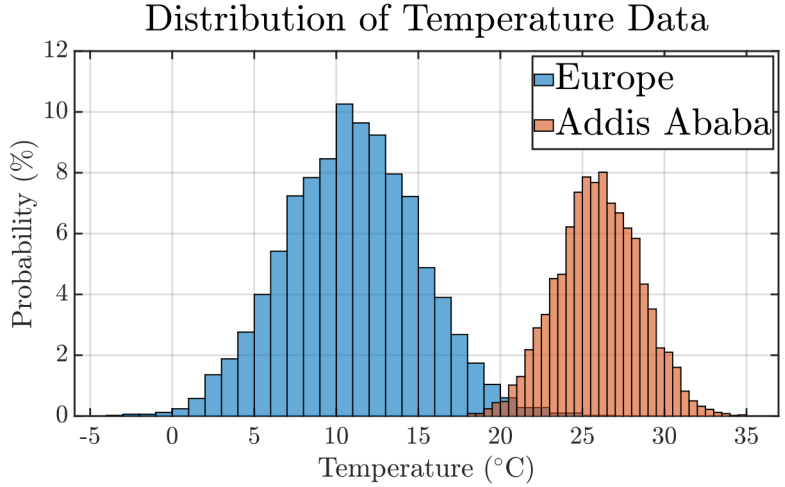
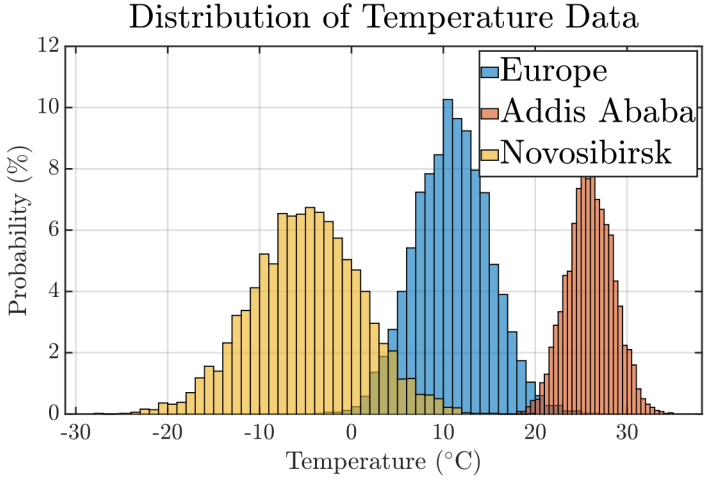
The static data assumption rarely holds in the real world

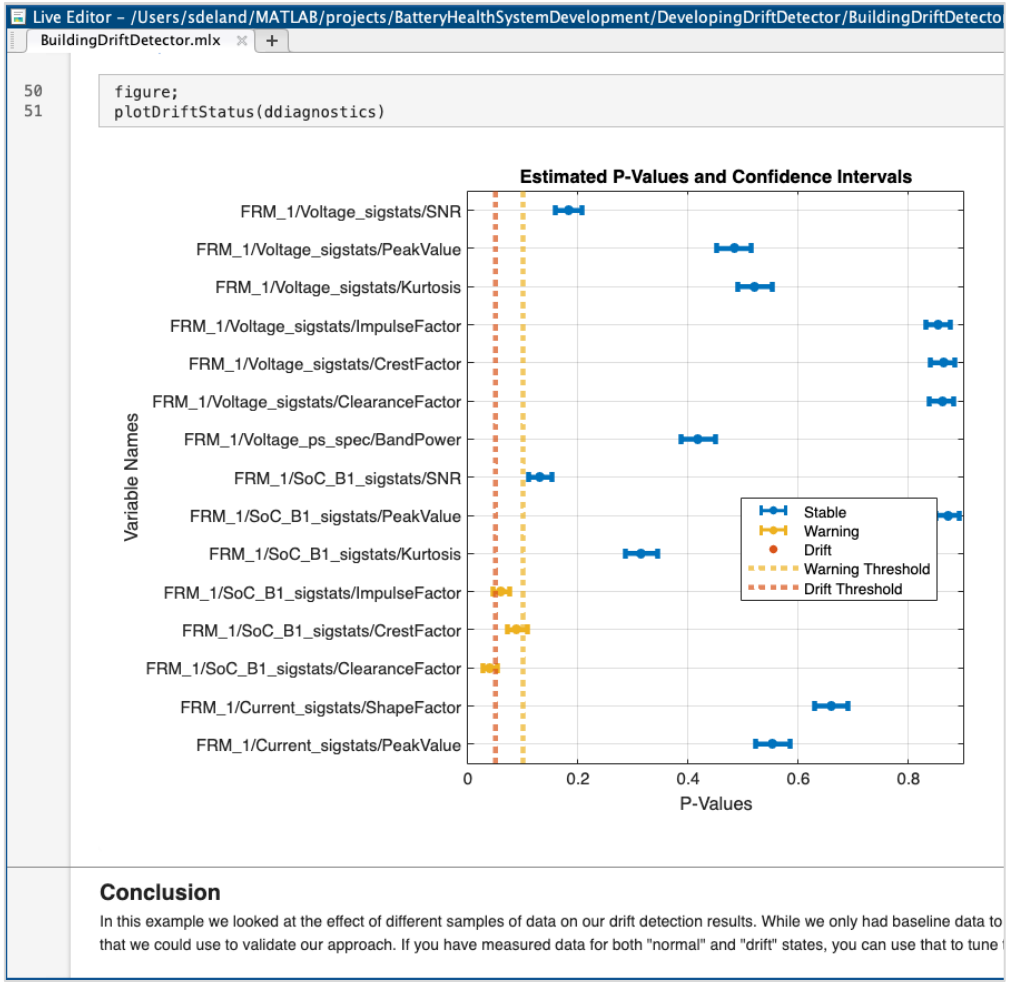






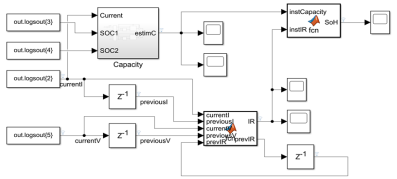
Developing drift detection with `detectdrift`

- Use historical data (training data) to create a baseline distribution
- Generate synthetic data to test for drift
  - This will be replaced by streaming data in the production system

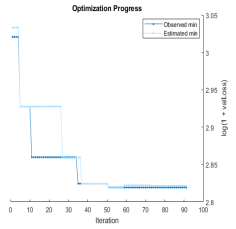


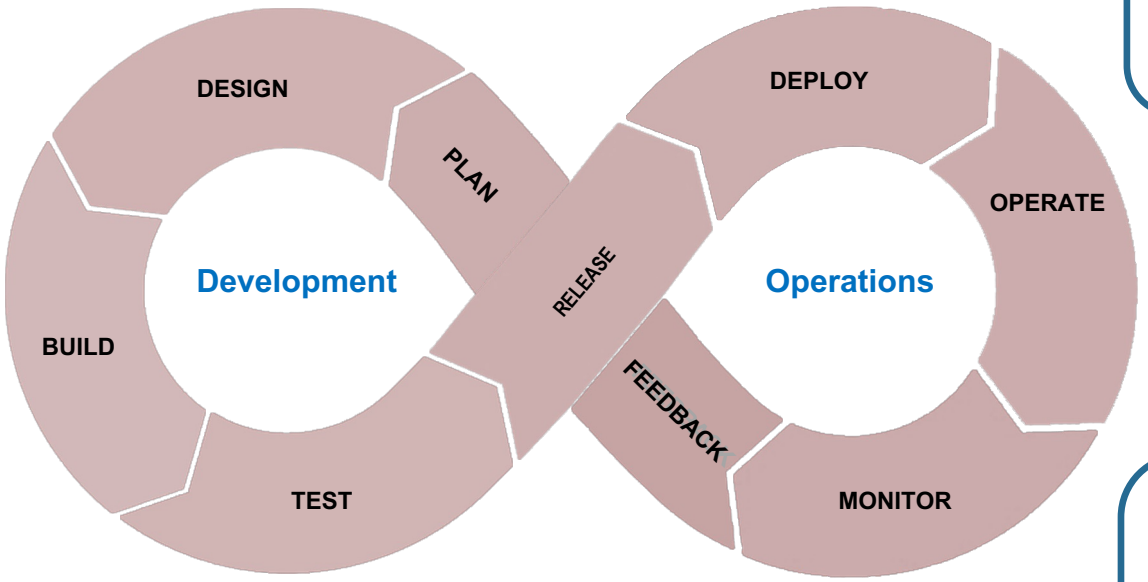
Update model when drift is detected

Data labeling



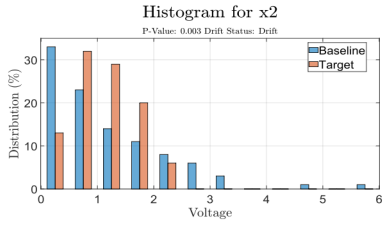
Retrain



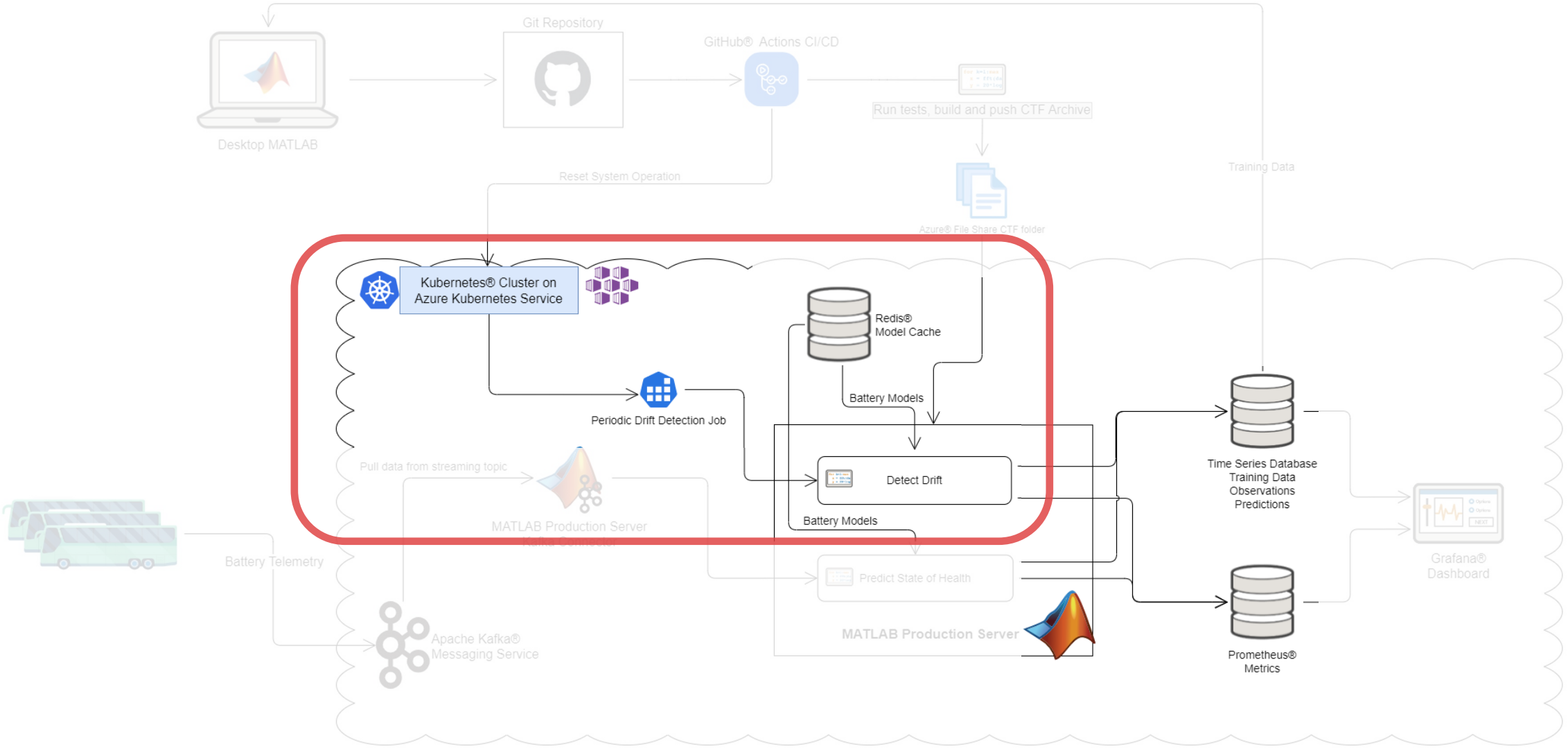


$$\hat{f}_2(x)$$

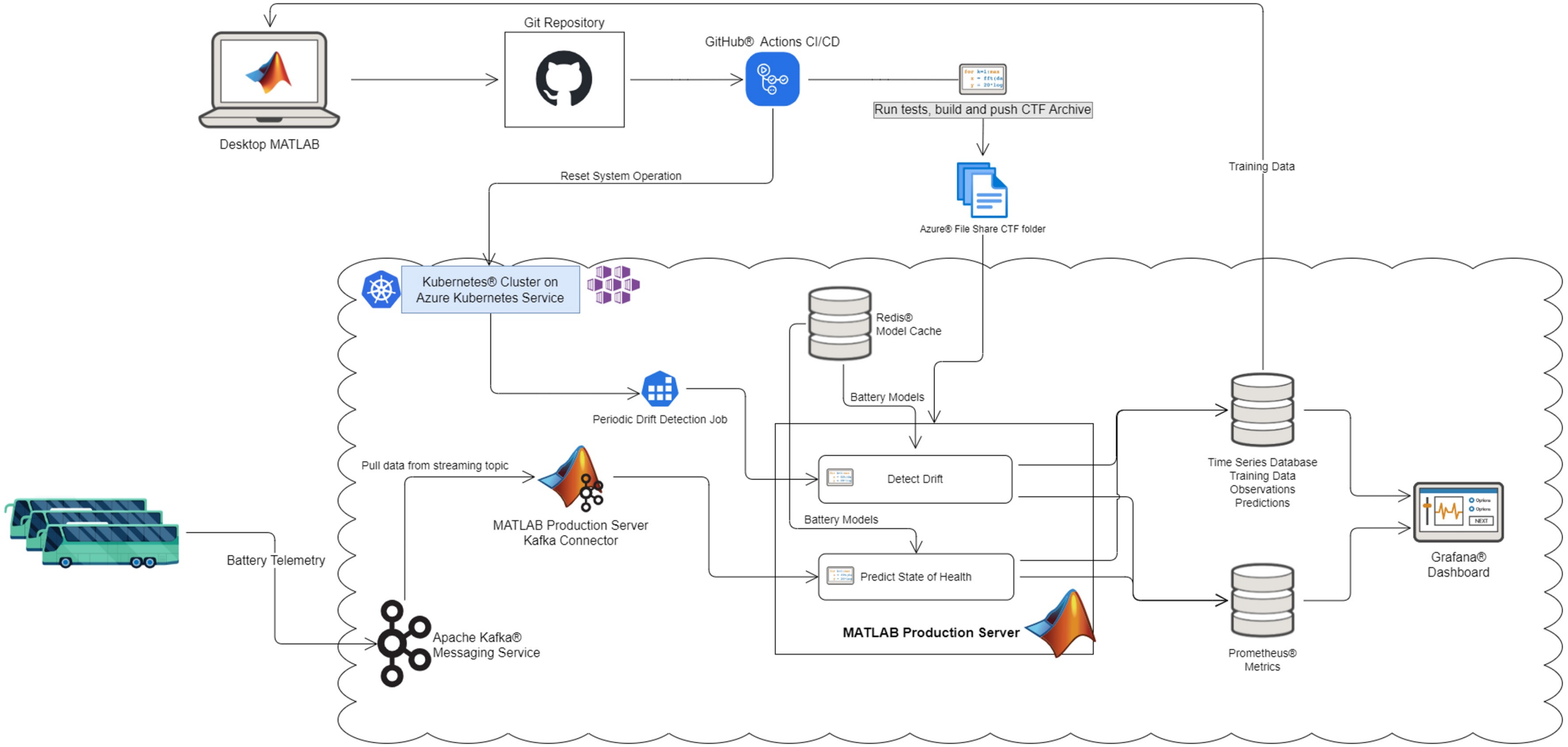
Drift Detection



Update infrastructure to periodically run the drift detection function



The Complete System



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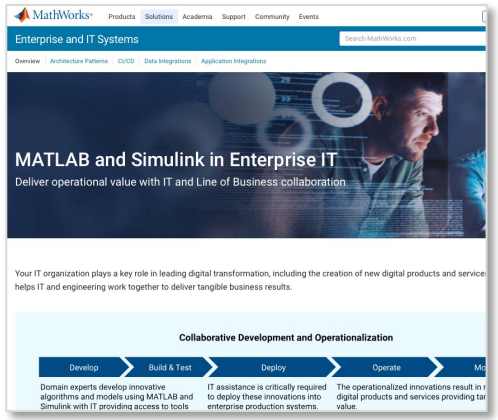
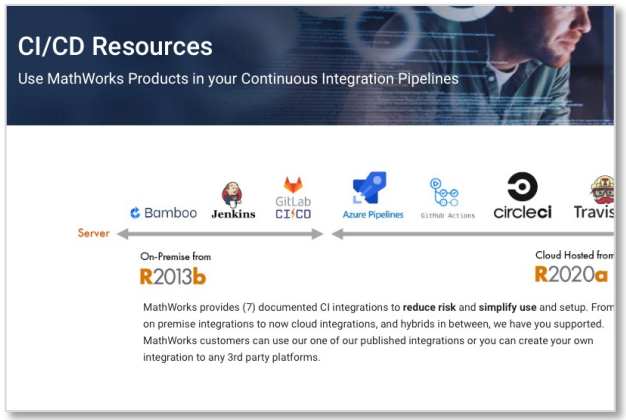
Learn More



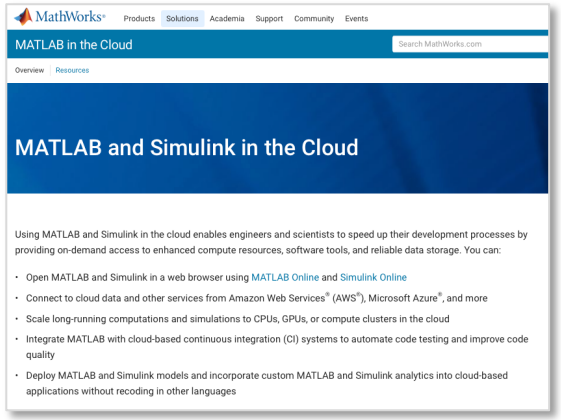
How MATLAB and Simulink are used with Enterprise IT

https://www.mathworks.com/solutions/enterprise-it-systems.html



CI/CD Resources

https://www.mathworks.com/solutions/enterprise-it-systems/ci-cd.html



MATLAB and Simulink in the Cloud

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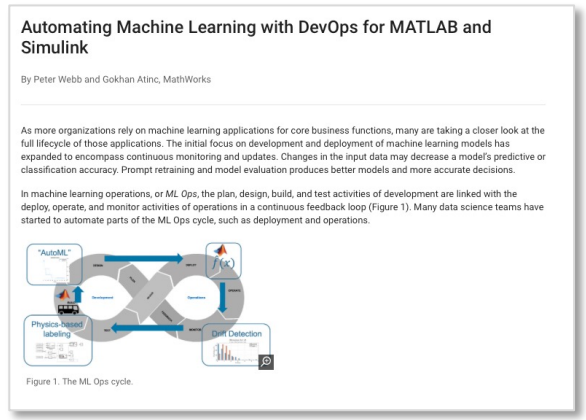

Automating Machine Learning with DevOps for MATLAB and Simulink

https://www.mathworks.com/company/newsletters/articles/automating-machine-learning-with-devops-for-matlab-and-simulink.html

Questions?

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