

MATLAB EXPO 2019

Industrial IoT and Digital Twins



Key Takeaways

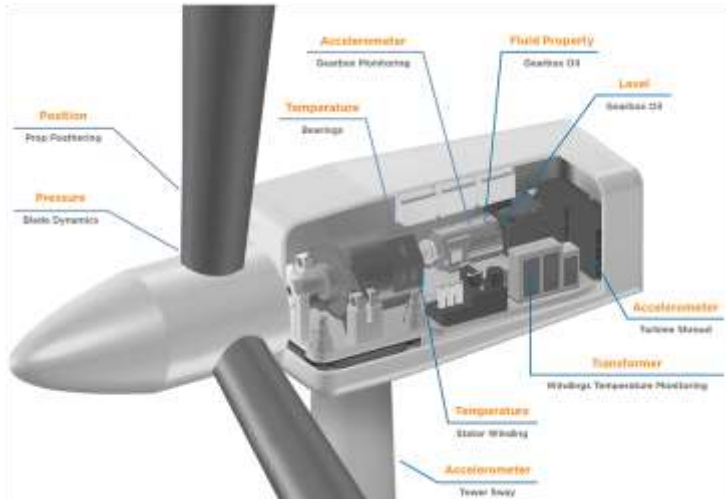
- You can use MATLAB and Simulink for IIoT and Digital Twin applications, leveraging their strong modeling, system simulation, and data analytics capabilities
- MathWorks' pilot and consulting teams can help you get your project started with applications such as predictive maintenance, operations optimization, and fleet management

Megatrend: Digital Transformation and IoT

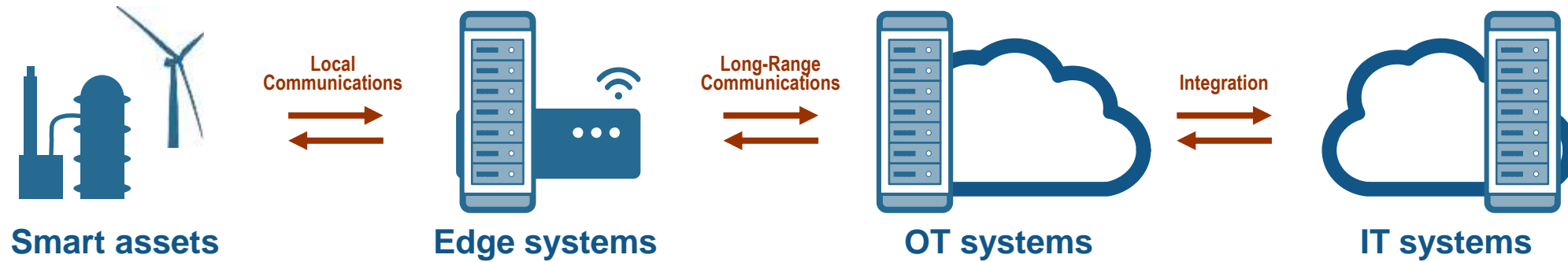
Overall Goals

By connecting machines in operation you can use data, algorithms, and models to make better decisions, improve processes, reduce cost, improve customer experience.

- Industrial IoT
- Digital Twin
- Industry 4.0
- Smart 'XYZ'
- Digital Transformation

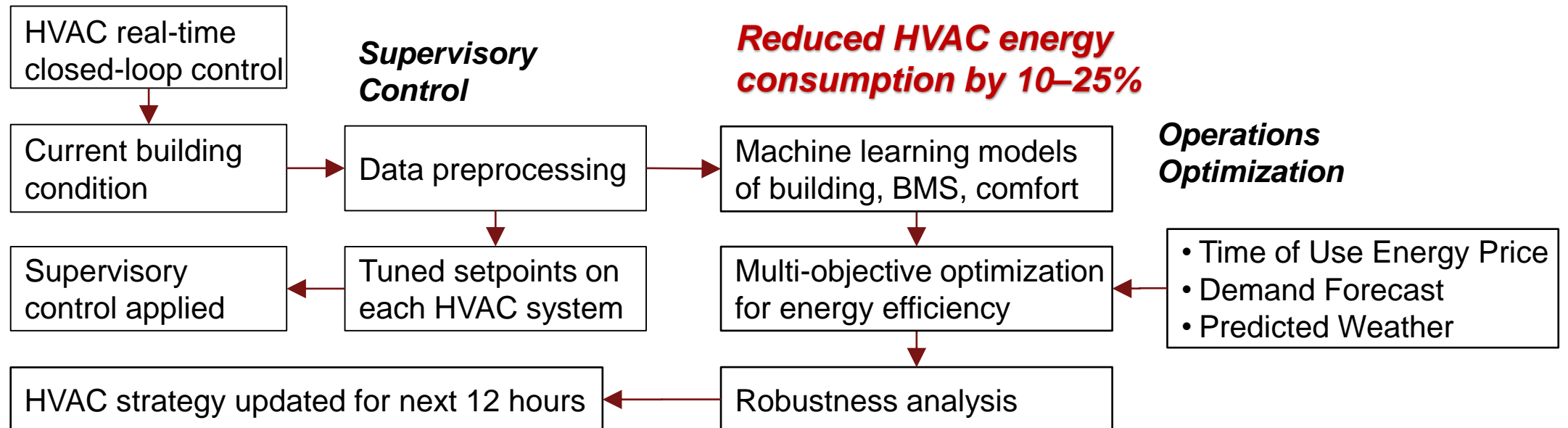
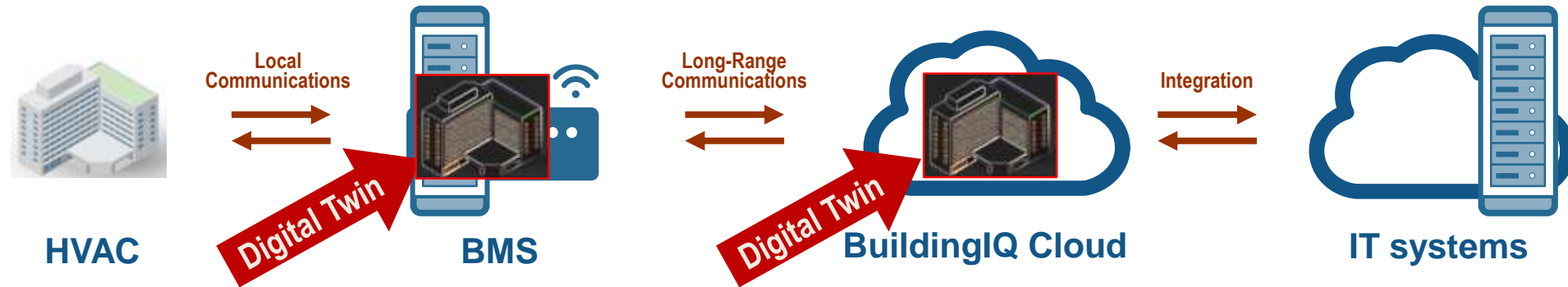


Organizations are Defining Infrastructure for Digitalization

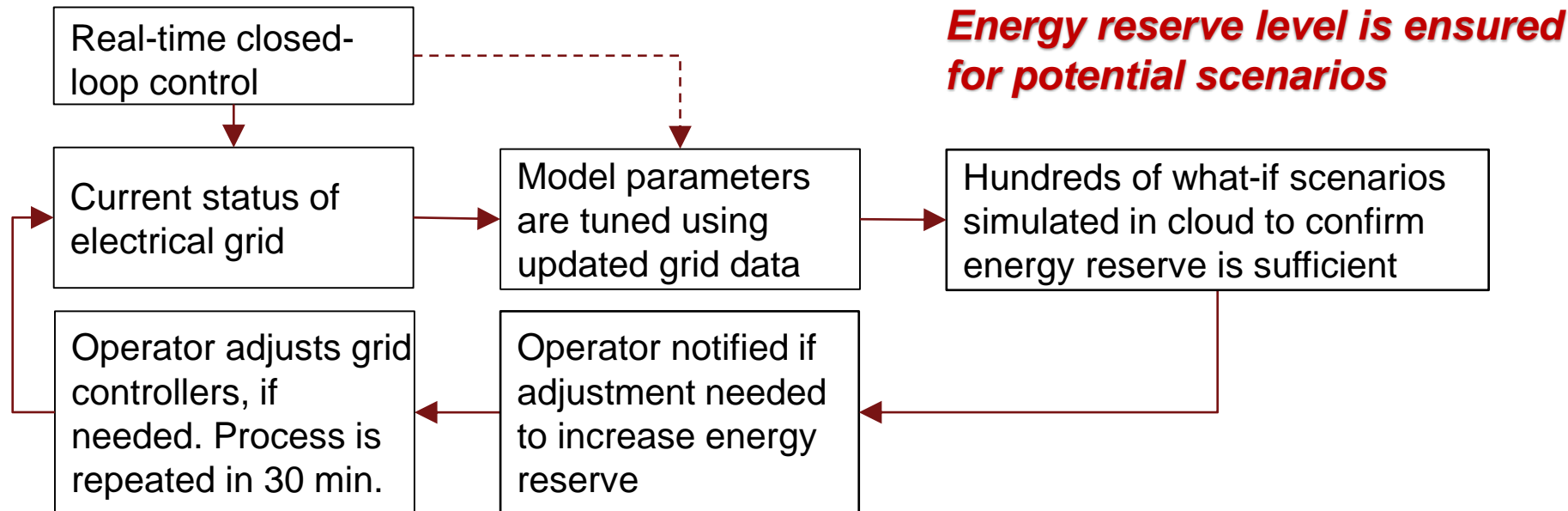
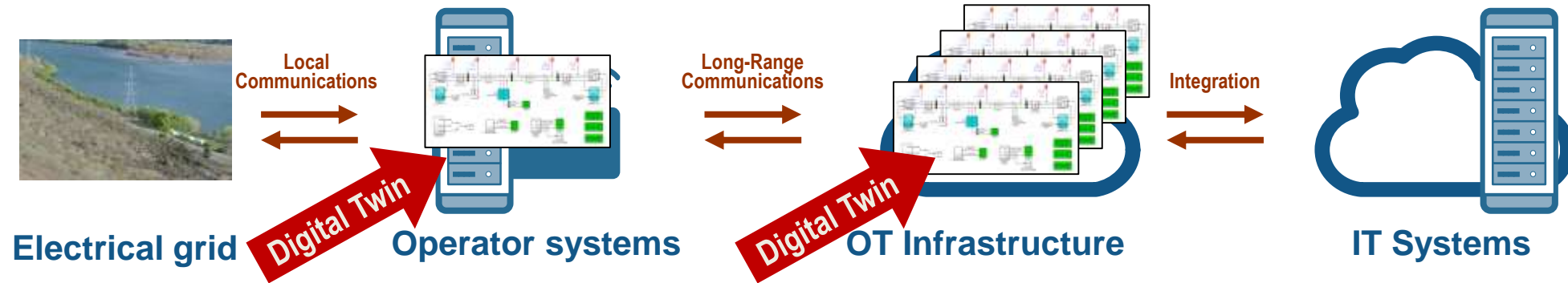


How are these used in an actual application?

Operations Optimization: BuildingIQ



Performance Management: Electrical Grid Operator



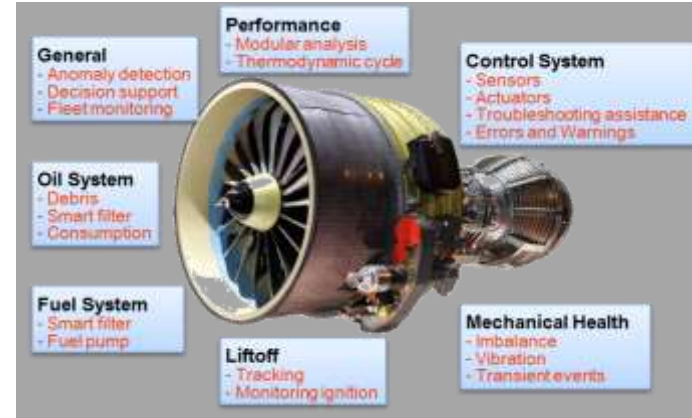
Other Examples of Digital Twins Across Industries



Commercial Vehicles
Driving-data logs and digital twin used to verify and tune automatic braking system



Space
Controller retuned to adjust for degraded thruster, confirmed with digital twin, and uploaded during deep space mission

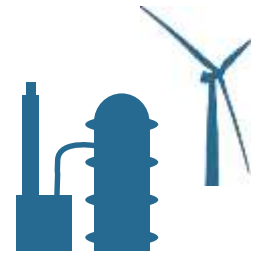


Aerospace
Operation data used to plan maintenance, improve aircraft availability, and reduce engine out-of-service time



Industrial Automation
Statistical models constantly updated to inform operators when plant is performing outside of optimal range

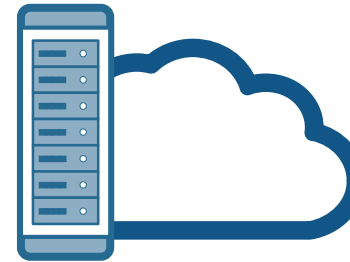
Applications at the Asset, the Edge, or Operational Technology Platform



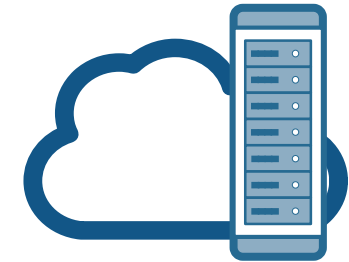
Smart assets



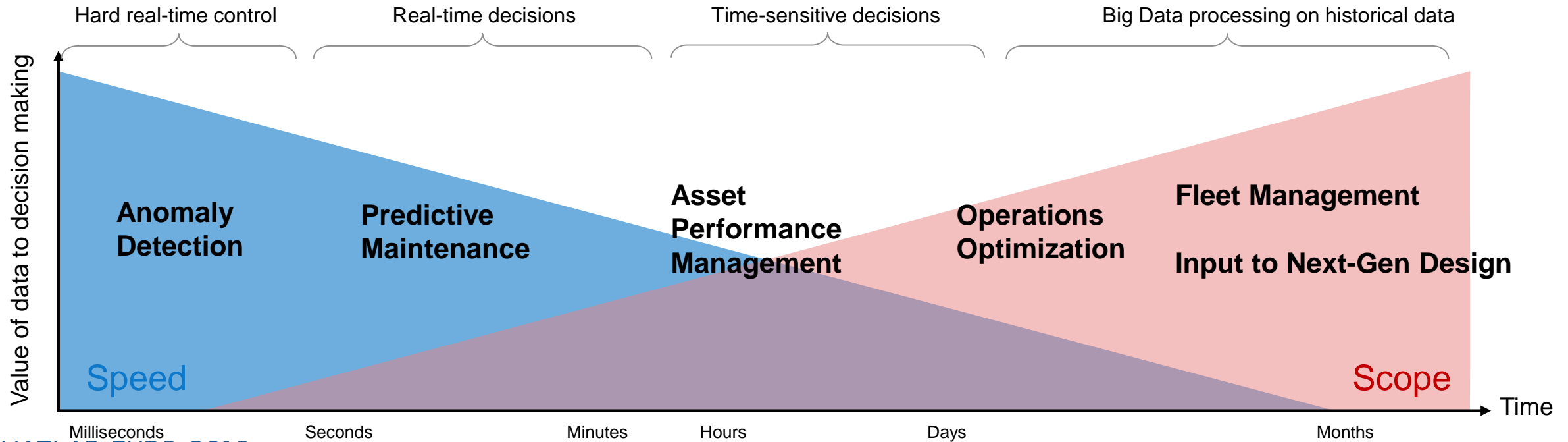
Edge systems



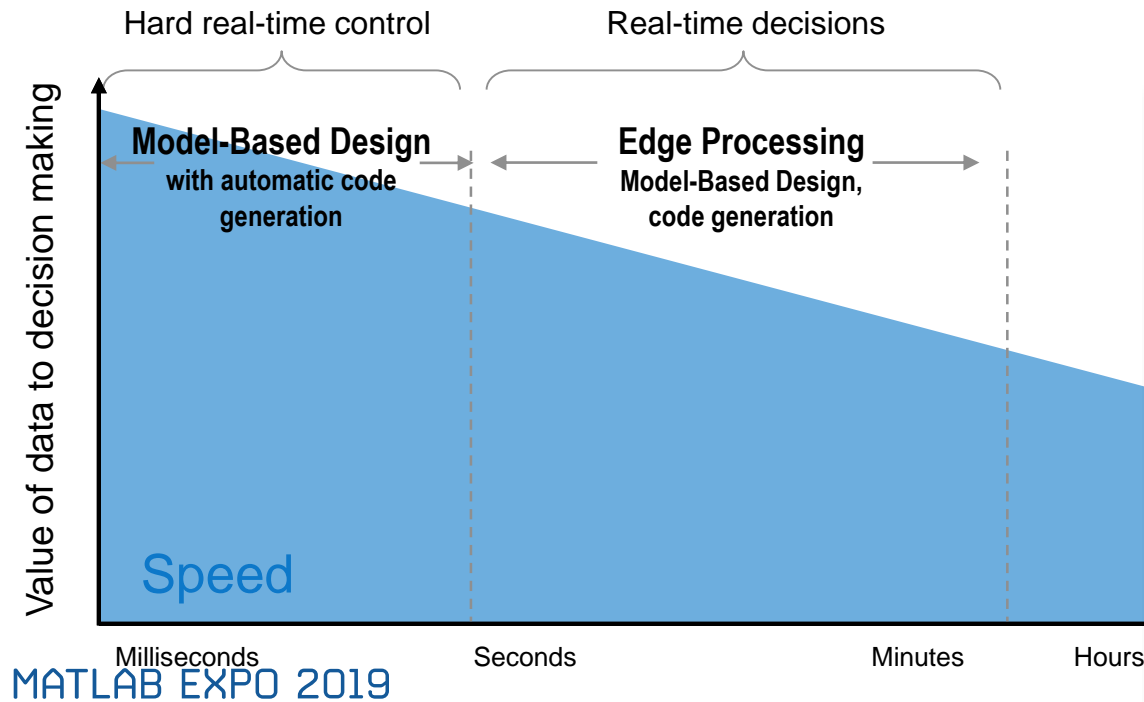
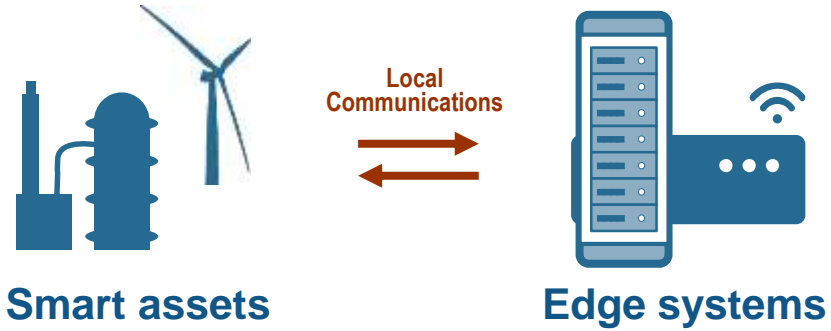
OT Infrastructure



IT Systems



Development for Fast and Highly-Deterministic Systems



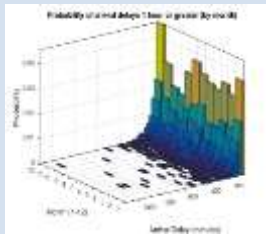
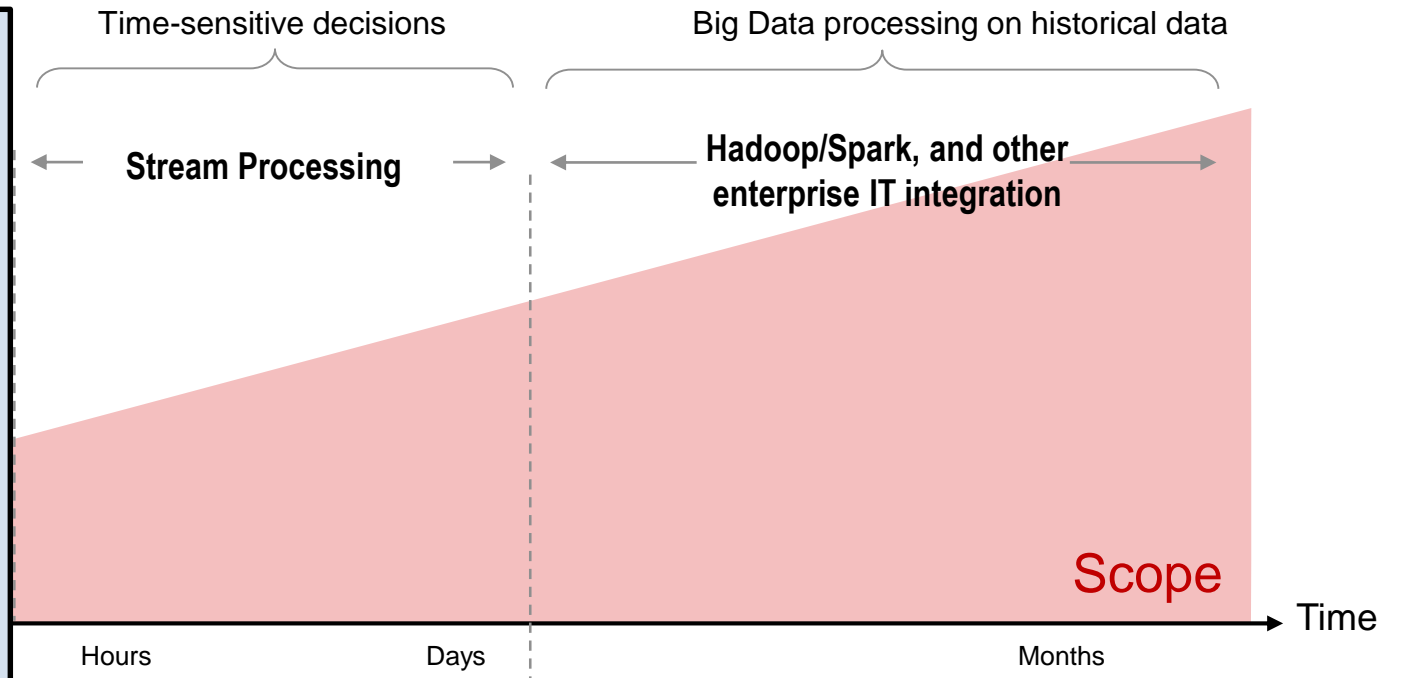
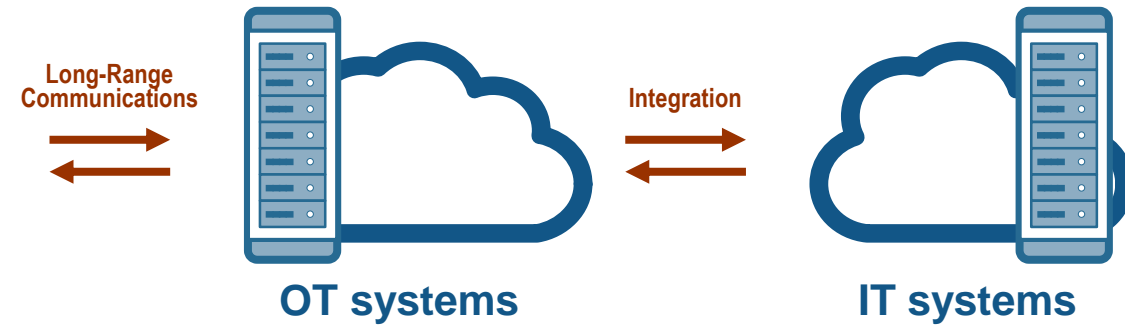
Model-Based Design

Multi-domain system modeling

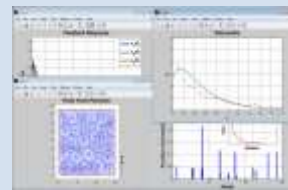
Parameter estimation

Automatic code generation

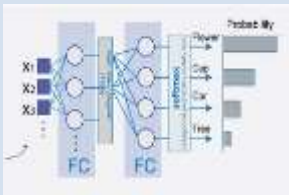
Development to OT/IT On-Prem and in Cloud



Variety and Volumes of Data



Optimization

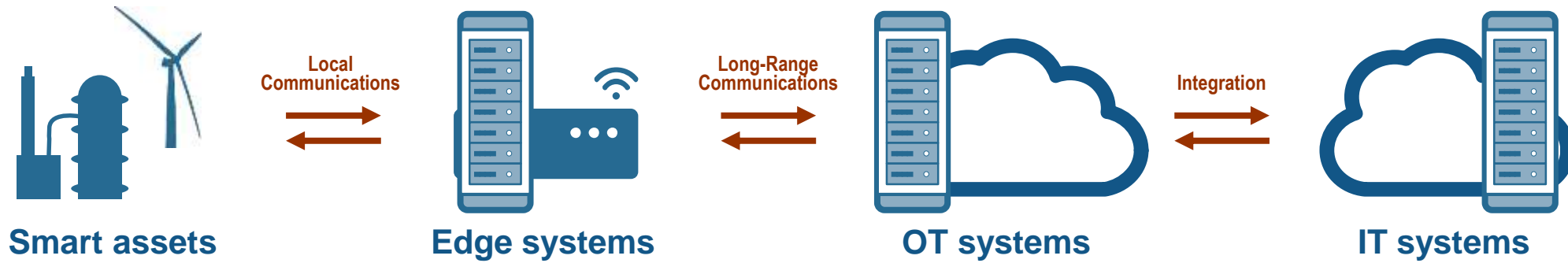


Machine Learning and Deep Learning



Enterprise system integration, (on-prem/cloud)

A Complex Collection of Tools, Platforms and Protocols



TCP/IP

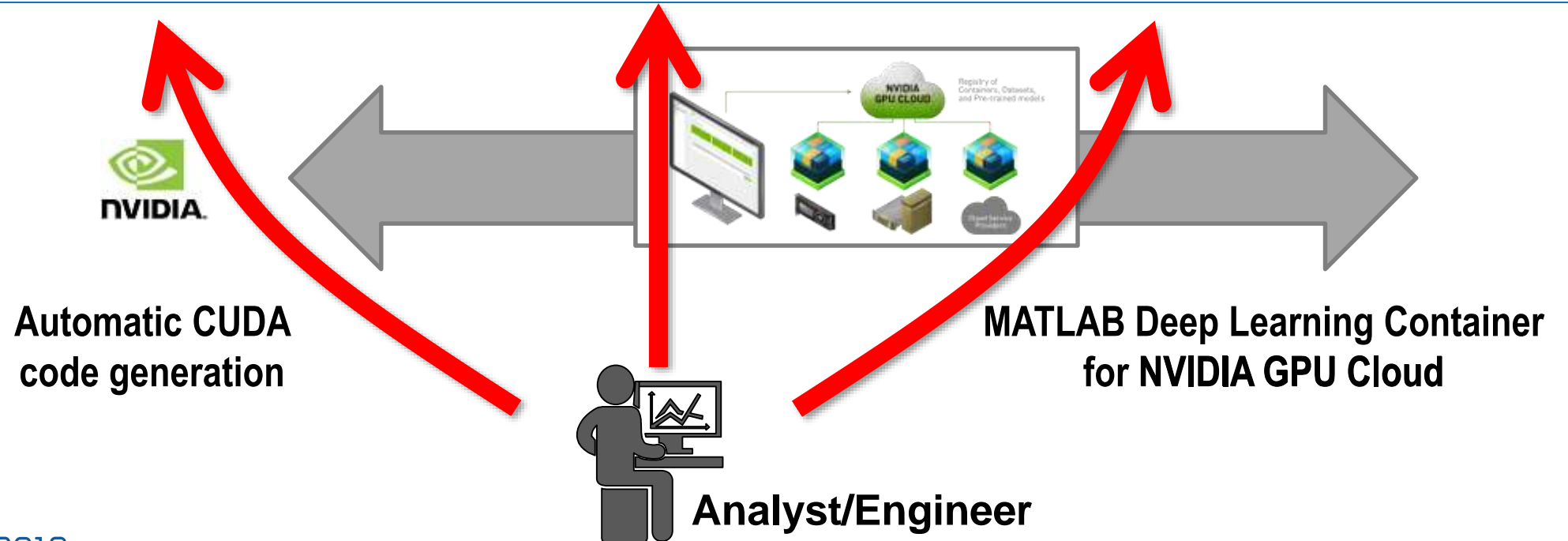
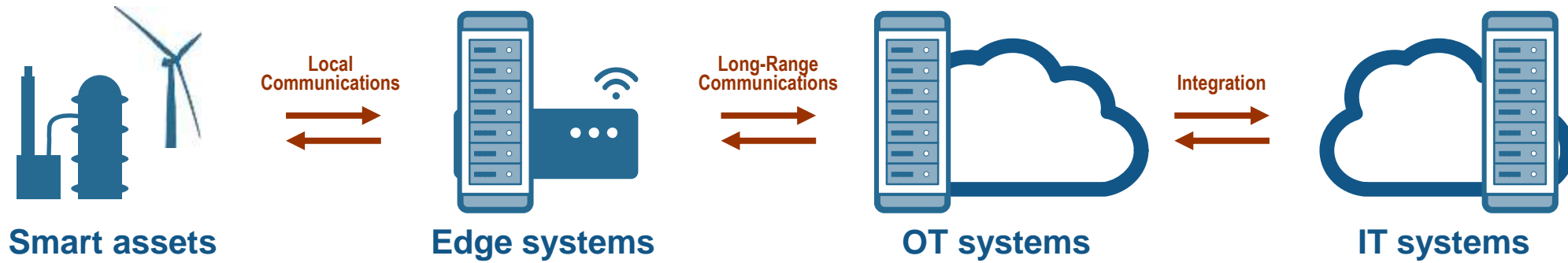
Rest APIs

Windows

MindSphere

Analyst/Engineer

A Complex Collection of Tools, Platforms and Protocols



Example Problems with a Triplet Replicating Pump



Triplex Pump

1 *Fault Classification is a time consuming manual process*

Current system requires operator to manually monitor operational metrics for anomalies. Their expertise is required to detect and take preventative action

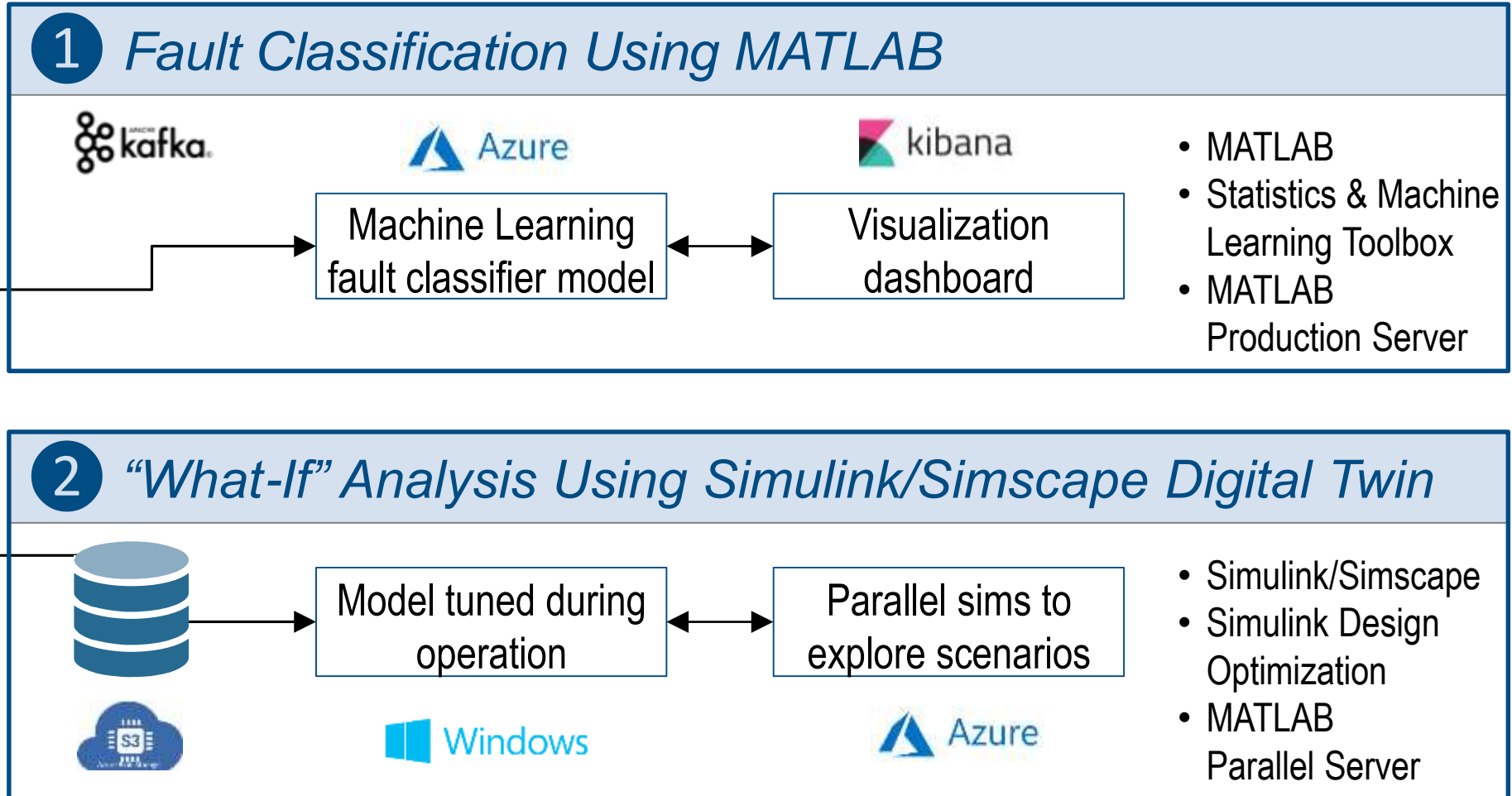
2 *Trouble using data to update digital twin and make use of it*

Current system gathers operational data from the pump, but not expertise on how to leverage data to update the digital twin and apply it to run what-if analysis in a scalable way

Two Demos



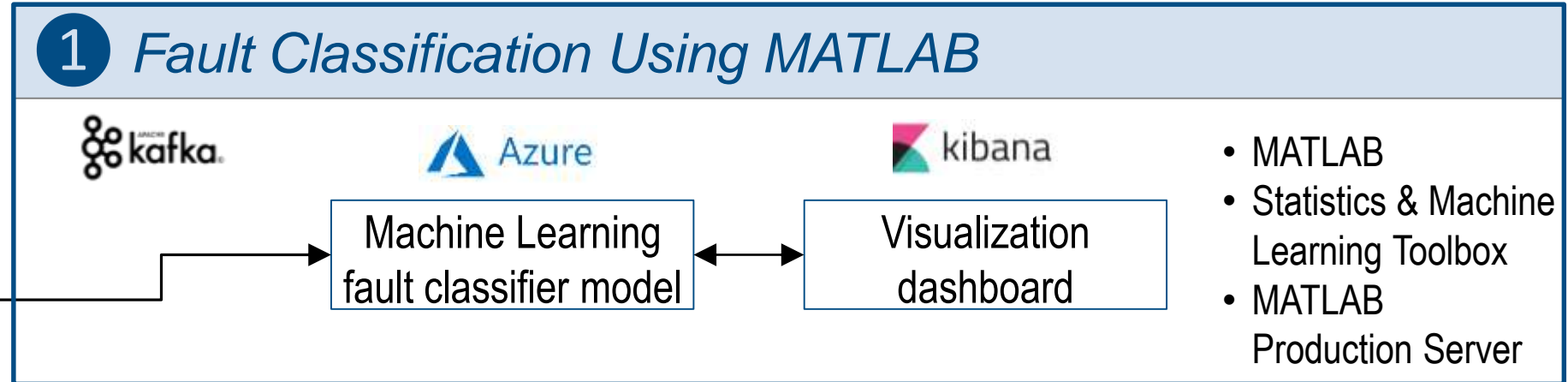
Triplex Pump



Demo 1



Triplex Pump

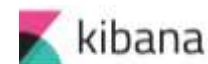


Fault Classification is a time consuming manual process

Current system requires operator to manually monitor operational metrics for anomalies. Their expertise is required to detect and take preventative action

Demo 1

1 Fault Classification Using MATLAB



Machine Learning
fault classifier model

Visualization
dashboard

- MATLAB
- Statistics & Machine Learning Toolbox
- MATLAB Production Server



Triplex Pump

Data:

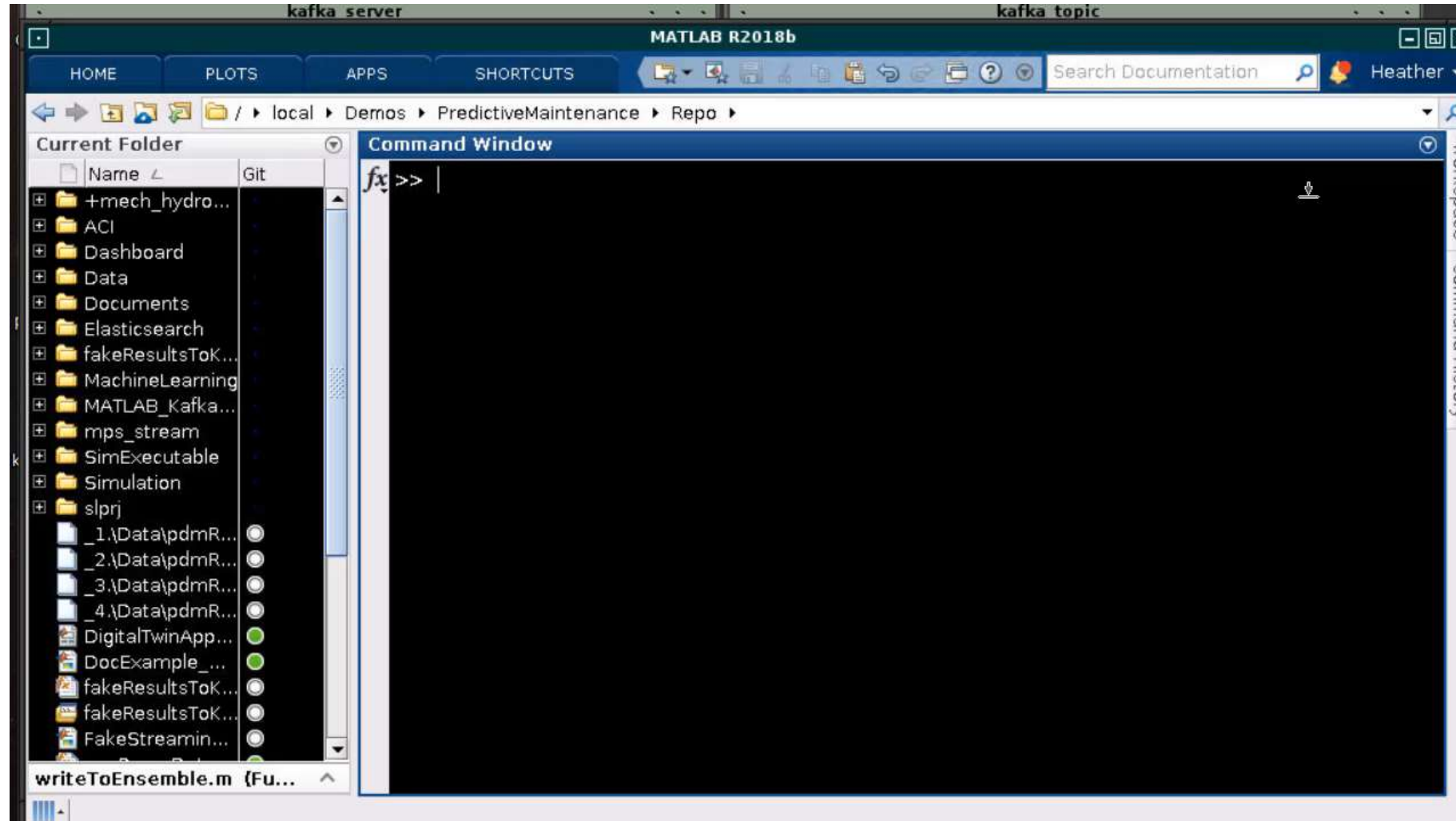
- Processed in chunks or
- Streaming continuously via Kafka

- A previously designed classifier, processes incoming stream, identifying faults
- Processing is elastic and can scale to any number of incoming streams/pumps via MATLAB Production Server

- Visualization dashboard (Kibana) shows data stream and deduced fault classification

Visualize Results

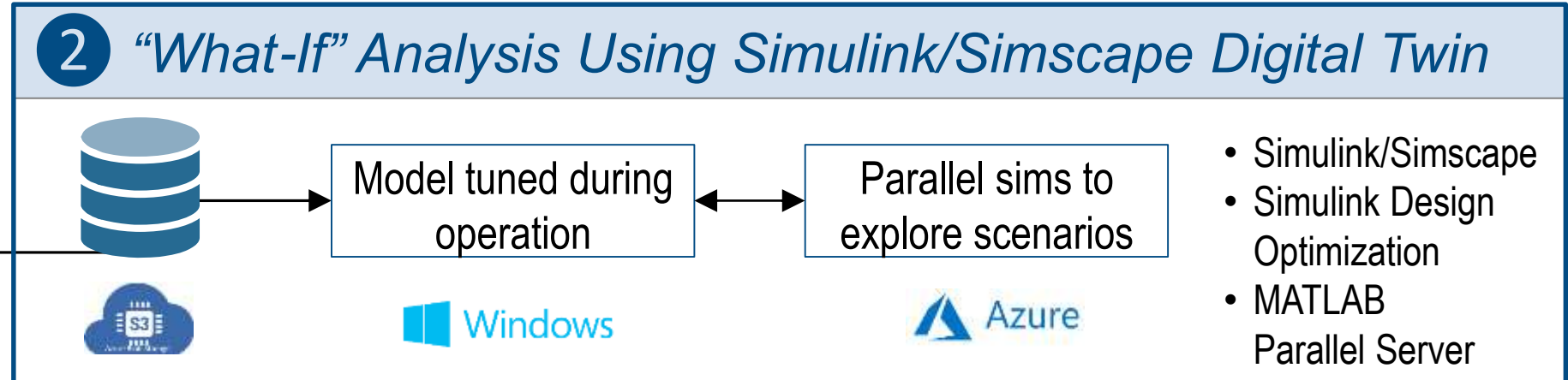
Complete Your Application



Demo 2



Triplex Pump



Trouble using data to update digital twin and make use of it

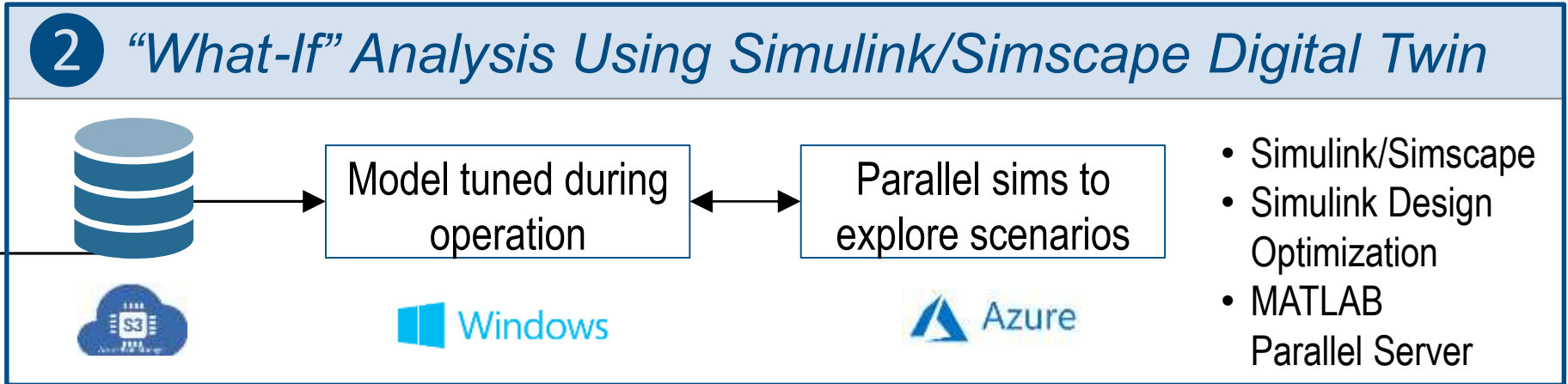
Current system gathers operational data from the pump, but not expertise on how to leverage data to update the digital twin and apply it to run what-if analysis in a scalable way

Demo 2

2 "What-If" Analysis Using Simulink/Simscape Digital Twin

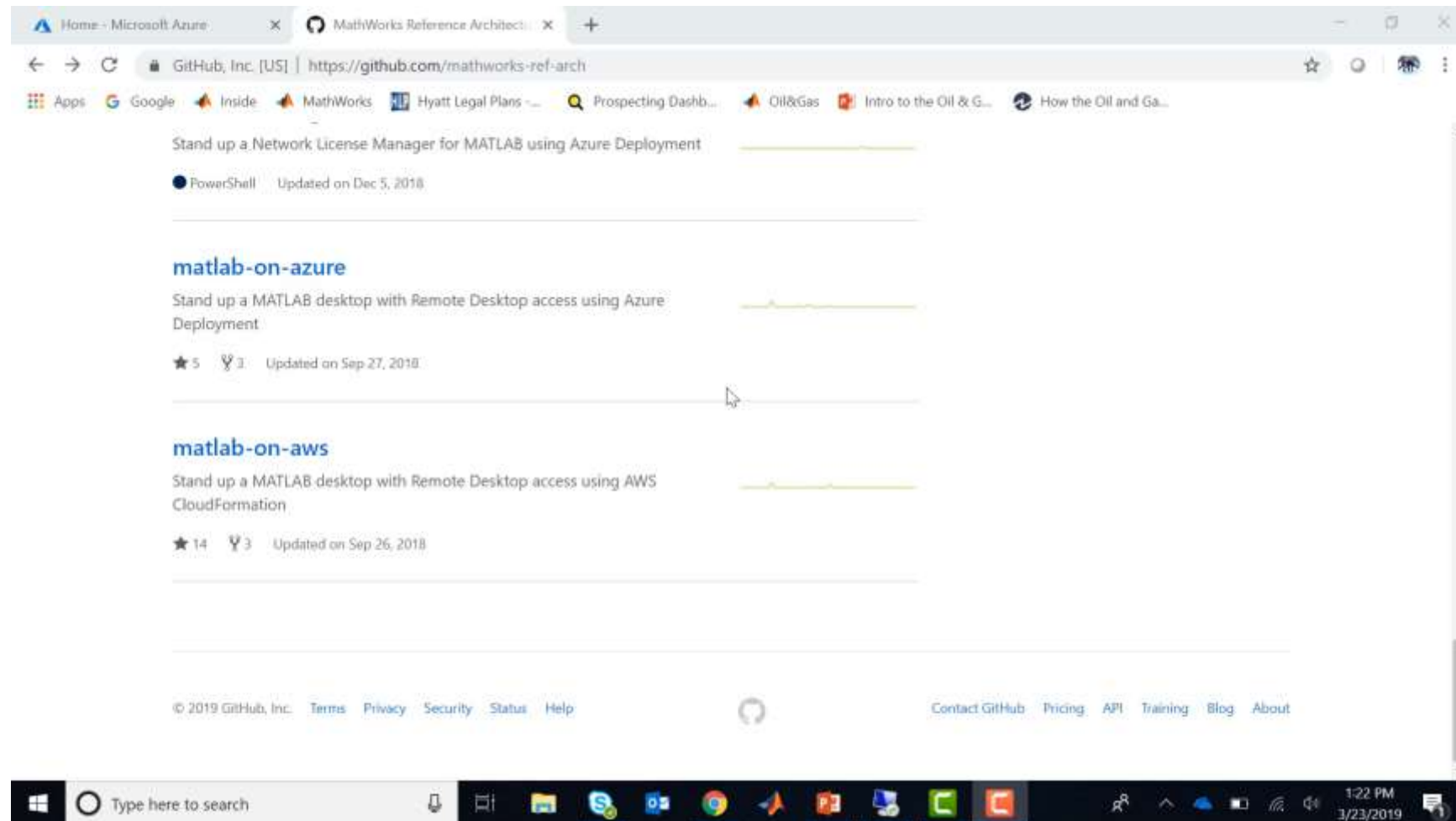


Triplex Pump



- Data streaming from asset, saved and selected for tuning using cloud storage connectivity
- Tune Digital Twin Parameters from latest available data from real asset using Simulink Design Optimization
- Run 100s "what-if" Scenarios with Parallel Server reference architecture on Azure
- Process output for possible operational decision

Demo 2 part I: Setting up MATLAB Reference Architect on Azure

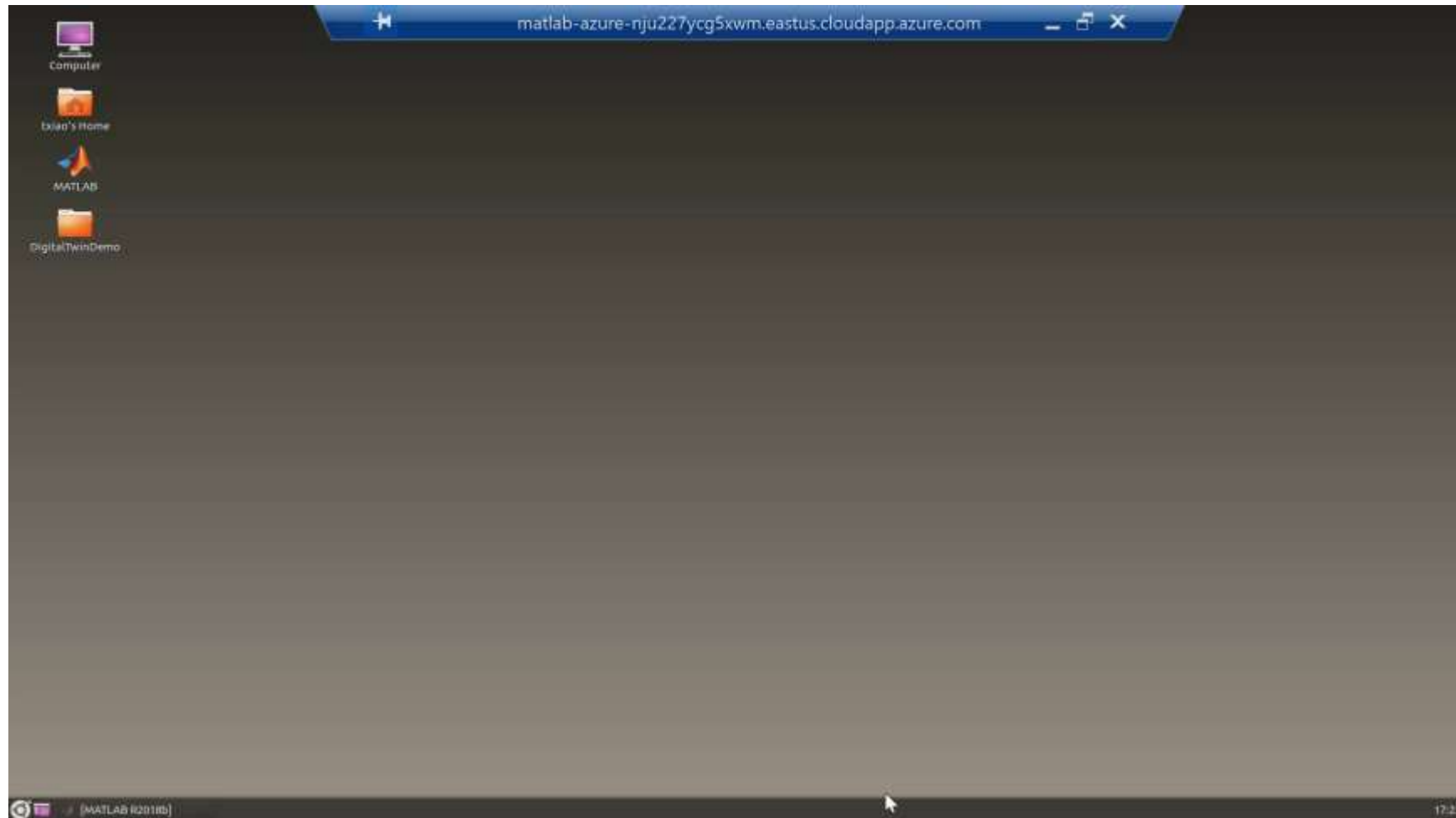


The screenshot shows a web browser window displaying the GitHub repository page for 'mathworks-ref-arch'. The browser's address bar shows the URL 'https://github.com/mathworks-ref-arch'. The page content includes three repository entries:

- Stand up a Network License Manager for MATLAB using Azure Deployment**
PowerShell Updated on Dec 5, 2018
- matlab-on-azure**
Stand up a MATLAB desktop with Remote Desktop access using Azure Deployment
★ 5 🗨 3 Updated on Sep 27, 2018
- matlab-on-aws**
Stand up a MATLAB desktop with Remote Desktop access using AWS CloudFormation
★ 14 🗨 3 Updated on Sep 26, 2018

The footer of the page includes copyright information for 2019 GitHub, Inc. and links for Terms, Privacy, Security, Status, Help, Contact GitHub, Pricing, API, Training, Blog, and About. The Windows taskbar at the bottom shows the search bar, task view, and various application icons, with the system tray displaying the time as 1:22 PM on 3/23/2019.

Demo 2 Part II: Updating Digital Twin with Parameter Estimation



Demo 2 Part III: Run What-if Analysis From Current State

The screenshot displays the MATLAB R2018b environment. The main window shows a block diagram of a 'Triple Pump with Fault' system. The script editor is open to 'main.m', which contains the following code:

```

1 % Set Up
2 startup_sm_pump_triplex
3
4 % SDO
5 sm_pump_triplex_paramest_compare
6
7 % Param
8 param_sm_pump_triplex
9
10

```

The Command Window shows the execution of the script, including the command `bdclose all` and the path to the Simscape Multibody Multiphysics Library v2.7. The Workspace window displays a list of variables and their values, such as `bearing_fault_f...` with a value of `3.0000e-04`.

Two of Many Options



Triplex Pump

- In addition to the approaches shown in these two demos, there are other ways to use MATLAB and Simulink to operationalize your applications
- These include running MATLAB and Simulink directly on the platform, deploying compiled applications, running generated code, and more
- We can work with you to define the right approach, based on your application requirements

In Conclusion

- You can use MATLAB and Simulink for IIoT and Digital Twin applications, leveraging their strong modeling, system simulation, and data analytics capabilities
- MathWorks' pilot and consulting teams can help you get your project started with applications such as predictive maintenance, operations optimization, and fleet management

Call to Action:

Talk to us about your IIoT and Digital Twin applications today

IIoT and Digital Twin Relevant Solution Pages

- [A view on the breath of MathWorks IIoT integration options](#)
- [MathWorks support on-prem and public cloud operations](#)
- [Physical Modeling](#)
- [Predictive Maintenance](#)
- [Data Science with MATLAB](#)
- [MathWorks products access for startups](#)
- [Service offering with consulting](#)
- [Third Party Connections](#)