Key Takeaways

- To support Industrial IoT and Digital Twin applications we extended our modeling, simulation and data analytics capabilities to all levels of enterprise digitalization systems

- Get started with MathWorks’ specialists for training and project support
  - predictive maintenance,
  - operations optimization,
  - 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**

- **HVAC real-time closed-loop control**
- **Current building condition**
- **Supervisory control applied**
- **HVAC strategy updated for next 12 hours**
- **Supervisory Control**
  - Data preprocessing
  - Tuned setpoints on each HVAC system
  - Machine learning models of building, BMS, comfort
  - Multi-objective optimization for energy efficiency
  - Robustness analysis

- **Operations Optimization**
  - Time of Use Energy Price
  - Demand Forecast
  - Predicted Weather

**Reduced HVAC energy consumption by 10–25%**
Performance Management: **Transpower**

Real-time closed-loop control:
- Operator notified if adjustment needed to increase energy reserve.
- Operator adjusts grid controllers, if needed. Process is repeated in 30 min.

Current status of electrical grid:
- Model parameters are tuned using updated grid data.

Energy reserve ensured for 100s scenarios:
- Hundreds of what-if scenarios simulated in cloud to confirm energy reserve is sufficient.

Integration:
- Local Communications
- Long-Range Communications
- Integration
- IT Systems
- OT Infrastructure

Electrical grid
- Operator systems
- Digital Twin

Local Communications
- Operator systems
- Digital Twin

Long-Range Communications
- Digital Twin

IT Systems
- Integration

MATLAB EXPO 2019
Other Examples of Digital Twins Across Industries

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

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

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

**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

**Value of data to decision making**

- **Anomaly Detection**
- **Predictive Maintenance**
- **Asset Performance Management**
- **Operations Optimization**
- **Fleet Management**

**Time**

- Milliseconds
- Seconds
- Minutes
- Hours
- Days
- Months

**Speed**

- Hard real-time control
- Real-time decisions
- Time-sensitive decisions
- Big Data processing on historical data

**Scope**

MATLAB EXPO 2019
Development for Fast and Highly-Deterministic Systems

Smart assets → Edge systems

Model-Based Design
with automatic code generation

Edge Processing
Model-Based Design, code generation

- Hard real-time control
- Real-time decisions

Value of data to decision making

Speed

Milliseconds → Seconds → Minutes → Hours

Multi-domain system modeling
Parameter estimation
Automatic code generation

Model-Based Design

CODE GENERATION

VHDL, Verilog, C, C++, Structured Text

MATLAB EXPO 2019
Development to OT/IT On-Prem and in Cloud

- Stream Processing
- Hadoop/Spark, and other enterprise IT integration
- Variety and Volumes of Data
- Machine Learning and Deep Learning
- Enterprise system integration, (on-prem/cloud)
- Optimization

Time-sensitive decisions
Big Data processing on historical data

Long-Range Communications
Integration

OT systems
IT systems

Scope
Time

- Machine Learning
- Enterprise system integration, (on-prem/cloud)
- Optimization

Variety and Volumes of Data

- Hours
- Days
- Months
A Complex Collection of Tools, Platforms and Protocols

Smart assets → Edge systems → OT systems → IT systems

Local Communications ↔ Long-Range Communications → Integration

TCP/IP

Rest APIs

Azure Stream Analytics

Analyst/Engineer

MATLAB EXPO 2019
A Complex Collection of Tools, Platforms and Protocols

Smart assets  Edge systems  OT systems  IT systems

Local Communications  Long-Range Communications  Integration

MATLAB Deep Learning Container for NVIDIA GPU Cloud

Automatic CUDA code generation

Analyst/Engineer
Two Demos based on a Triplex Pump

1. **Fault Classification using MATLAB**
   - Machine Learning fault classifier model
   - Visualization dashboard
   - **Tools**:
     - MATLAB
     - Statistics & Machine Learning Toolbox
     - MATLAB Production Server

2. **“What-If” Analysis using Simulink/Simscape Digital Twin**
   - Model tuned during operation
   - Parallel sims to explore scenarios
   - **Tools**:
     - Simulink/Simscape
     - Simulink Design Optimization
     - MATLAB Parallel Server
Fault Classification using MATLAB

Manual fault classification is a time consuming process

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

Triplex Pump

Data:
- Processed in chunks or
- Streaming continuously via Kafka

Machine Learning fault classifier model

Visualization dashboard

- 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 shows data stream and deduced fault classification

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

Azure
kibana
“What-If” Analysis using Simulink/Simscape Digital Twin

Model tuned during operation → Parallel sims to explore scenarios

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.
“What-If” Analysis using Simulink/Simscape Digital Twin

- Setting up MATLAB Reference Architecture on Azure
  https://github.com/mathworks-ref-arch

- Updating Digital Twin with Parameter Estimation

- Run “What-if” Analysis from Current State with Parallel Simulations

Triplex Pump
“What-If” Analysis using Simulink/Simscape Digital Twin

- Model tuned during operation
- Parallel sims to explore scenarios
- 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

Triplex Pump

- Simulink/Simscape
- Simulink Design Optimization
- MATLAB Parallel Server
Two of Many Options: We can Help!

“MATLAB enabled us, as geologists, to use our expertise in predictive frameworks, analytics, and analog matching to implement algorithms that are unique in our industry. With the help of MathWorks consultants, we then deployed those algorithms as an easy-to-use application to our colleagues worldwide.”

Nick Howes, Shell
Key Takeaways

- To support Industrial IoT and Digital Twin applications we extended our modeling, simulation and data analytics capabilities to all levels of enterprise digitalization systems

- Get started with MathWorks’ specialists for training and project support
  - predictive maintenance,
  - operations optimization,
  - fleet management,
  - …

Find out more:
Triplex pump with Condition Monitoring
  Tadele Shiferaw
Load Forecasting System
  Toon Weyens
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
Related Trainings

- Machine Learning
  - Machine Learning with MATLAB

- Speeding up code
  - Accelerating and Parallelizing MATLAB Code

- AppDesigner
  - Building Interactive Applications in MATLAB

Find out more:
Services Stand:
Training and Consulting

Marlies Terlouw
Titus Edelhofer

https://nl.mathworks.com/services/training.html