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Industry 4.0 and Digital Twins

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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

Reduced HVAC energy consumption by 10–25%
- 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

Local Communications
- Digital Twin

Long-Range Communications
- BuildingIQ Cloud
- Integration

IT systems

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Performance Management: TransPower

- Energy reserve level is ensured for potential scenarios

- Digital Twins are also used in other industries, like:
  - Automotive
  - Aerospace
  - Automation and Machinery

Real-time closed-loop control
Current status of electrical grid
Operator adjusts grid controllers, if needed. Process is repeated in 30 min.

Model parameters are tuned using updated grid data
Operator notified if adjustment needed to increase energy reserve

Hundreds of what-if scenarios simulated in cloud to confirm energy reserve is sufficient
Applications at the Asset, the Edge, or Operational Technology Platform

- **Smart assets**
- **Edge systems**
- **OT Infrastructure**
- **IT Systems**

**Value of data to decision making**
- **Speed**
  - Milliseconds
  - Seconds
  - Minutes
  - Hours
  - Days
  - Months

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

**Applications**
- Anomaly Detection
- Predictive Maintenance
- Asset Performance Management
- Operations Optimization
- Fleet Management
  - Input to Next-Gen Design

**Scope**

**MathWorks**

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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

Value of data to decision making

Hard real-time control

Real-time decisions

Speed

Milliseconds
Seconds
Minutes
Hours

Model-Based Design
- Multi-domain system modeling
- Parameter estimation
- Automatic code generation

V_PCC
P_PCC
P_SIM
Q_PCC
Q_SIM

CODE GENERATION

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Development to OT/IT On-Prem and in Cloud

Stream Processing

OT systems

Time-sensitive decisions

Big Data processing on historical data

Hadoop/Spark, and other enterprise IT integration

IT systems

Long-Range Communications

Integration

Variety and Volumes of Data

Optimization

Machine Learning and Deep Learning

Enterprise system integration, (on-prem/cloud)

Scope

Time

Hours

Days

Months
A Complex Collection of Tools, Platforms and Protocols

Smart assets → Local Communications → Edge systems

Edge systems → Long-Range Communications → OT systems

OT systems → Integration → IT systems

TCP/IP

Rest APIs

Analyst/Engineer

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Example Problems with a Triplex Replicating 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.
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

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.

Data: - Processed in chunks or - Streaming continuously via Kafka.
“What-If” Analysis using Simulink/Simscape Digital Twin

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](https://github.com/mathworks-ref-arch)

- Updating Digital Twin with Parameter Estimation

- Run “What-if” Analysis from Current State with Parallel Simulations
“What-If” Analysis using Simulink/Simscape Digital Twin

- Model tuned during operation
- Parallel sims to explore scenarios

- 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
  - Simulink/Simscape
  - Simulink Design Optimization
  - MATLAB Parallel Server
  - Process output for possible operational decision

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Find out more:
Load Forecasting System
Christoph Kammer
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

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