The role of Simulation and AI in the implementation of a Digital Twin

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Outline

• Todays challenges
• Main areas of interest from our customers
• Introduction to Digital Twins
• Different types of Digital Twin
• How IBM supports the Digital Twin
• Use cases for Digital Twins
  • Demo example
Today’s leaders of systems solutions face significant challenges.

In 2019, how to find new sources of productivity and acceleration....

Unprecedented opportunities & challenges for technology companies.

Engineering remains at the heart of innovation.

How to move engineering & innovation to a new level?

*Predictability*

*Productivity*

*Quality*

*Flexibility*
Industry vision: Digital Engineering initiative by US Department of Defense

“conduct engineering in more integrated virtual environments to increase customer and vendor engagement, improve threat response timelines, […], reduce cost of documentation and impact sustainment affordability.

Such engineering environments will allow DoD and industry partners to evolve designs at conceptual phase, reducing the need for expensive mockups, premature design lock, and physical testing.”

Some key concepts to support Digital Transformation in A&D

- Digital Twin
- Internet of Things
- Cyber Physical System for Connected Operations/Products
- Engineering for Connected Products
What is a Digital Twin?

“The Digital Twin is the virtual, state-full representation of a physical product and the system behind across its life-cycle using operational real-time data and other sources to enable understanding, learning, reasoning, and dynamically recalibrating for improved decision making"
Digital Twin is a journey

**Prototype Twin**
- As designed
  - Model-Based Systems Engineering
  - No physical object
  - No real-time data

**Production Twin**
- As built
  - Simulation-model with real-time data

**Service Twin**
- As maintained
  - Prediction
  - Augmented Reality
  - Physical object
  - Real-time data
Digital Thread for engineering collaboration

- A standards based engineering lifecycle management architecture and technology platform
- Linking data across disciplines and tools
- Central lifecycle knowledge graph for analytics
- Global configuration management for federated lifecycle tools

**Real-Time Testing**

**Electrical Design**

**Multi-domain Simulation**

**Product Line Engineering**

**Product Lifecycle Management**

**Global Configuration Management**

**Lifecycle Links**

**Lifecycle Graph (LQE)**

**Analysis and Design Models**

**Workflow Management**

**Test Management**

**Requirements Management**
Digital Thread = Collaboration of Toolchain
Digital thread as a Model
Digital Twin = Simulated representation of physical device

- Allows virtual testing and prototyping of the systems
  - State based models
  - Activity based models
- Hi Fidelity heterogenous models used to validate systems behavior requirements
Hybrid Simulation Platform supporting the Digital Twin

- Simulink model
- Computation algorithm
- System composition
- Textual requirements
- Contracts/ Simulation Monitors
- FMU1
- FMU2
- FMU3
- Models, designs and results repository
- Version control and dependency analysis
Digital Twin as a Digital Shadow enabled by IOT

Data from the real artifact captured and compared to information in the virtual prototype

Need to capture
- Environment conditions
- Operator inputs

Used to drive the Virtual model

Machine Learning can be used to understand the expected behavior
IBM Watson IoT Engineering Solution Architecture

- IBM Watson IoT Platform
- Watson Data Platform
- IBM Hybrid Cloud
- PLM
- MCAD/E CAD
- IBM Eng Apps (RM, AM, QM, CCM)
- OSLC
- Knowledge Graph (LQE)
- CE4IoT
- Production Quality Insights
- Asset Analytics (Predictive Maintenance etc)
- Asset Management
- MES
- AI
- Digital Twin apps
- Emerging
- 3rd Party Apps
- IBM Eng/Jazz
- IBM Cloud

IoT Exchange 2019 / Advances in AI for Engineering / Apr 23, 2019 / © 2019 IBM Corporation
Role of Digital Twins and Shadows

User

System

Control algorithm (state based)

Physical Components

Environment
Use cases for the digital twin:- SW and HW
Comparing information from a virtual model digital twin with a shadow digital twin from real systems

- **SW and HW**

  Comparing information from a virtual model digital twin with a shadow digital twin from real systems

**User**

**Control algorithm (state based)**

**Physical Components**

**System**

**Environment**

**Virtual DT**

**Development process**

Improve the fidelity of the Virtual model (simplify the model to rules)

Identify issues and faults with the system and trigger the change request process

Improve the algorithm being used in the real world (Over the Air Updates)

AI and Machine Learning algorithms can used to replace the control algorithm

Virtual digital twin can also be replaced by the ML algorithm
Heat Sensor

Alarm System

Compliance requirements:

Heating of the wing

Minimum: 10 °
Maximum: 26 °
Connecting IoT World & Engineering World

Engineering World = Jazz Platform

IoT World = IoT Platform

Market Analysis
Customer Requirements
System Requirements
System Design
Component Design
Implementation
Continuous Engineering

Operations and Maintenance
Deploy or Release to Mfg
System V & V
System Test
Component Test

Electrical / Electronics Design
Lean Software Engineering
Mechanical Design

System Under Test Conditions

Current Temperature
System Under Test Fault Free status
Test Environment health

Delcing Unit’s live data

Test Rig Control
Inject Out of limit Fault
Reset
Maximum Temperature °C
25
Minimum Temperature °C
9
Loading Interval [sec]
20
CLEAR CHART DATA

Current Temperature

22°C
IoT Platform
KPI: 10 °C – 26 °C

Temperature range: 10 °C – 26 °C
failed

New Task
Summary

• To enable a digital twin it requires the implementation of a digital thread
• Digital thread allows you identify
  • Impact of change
  • Root cause analysis
• Digital twin is used to reveal failures in the system by comparing digital shadow
  • IOT sensor data to requirements and/or model constraints
• Digital twin simulation consuming the IOT sensor data
• Digital twin can be used to do predictive fault analysis on the system based upon comparison of Virtual digital twin simulations and Shadow twin.
• ML can be used to represent physical and behavioural systems models
  • Very dependent upon the learning data being captured
• Engineering becomes an integrated part of your product lifecycle
Thank You

Any Questions ?