Exploring the Future of Digital Twins

David Cameron   Evgeny Kharlamov   Brandon Perry
Digital Twins

I. Motivators

II. Open challenges

III. Our work & engaging with us
Digital Twins
Now and Tomorrow
# The SIRIUS Centre

<table>
<thead>
<tr>
<th>Eight years’ financing from RCN</th>
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<tr>
<td>13 Industrial Partners (11 in 2017)</td>
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<td>3 Leading Academic Institutions: Oslo, NTNU Trondheim, Oxford</td>
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<td>Centre for Research-Based Innovation</td>
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<td>Funding for 20 Ph.D. students</td>
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<td>Innovation through prototypes and pilots</td>
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<td>45 affiliated researchers</td>
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<th>Equinor</th>
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<td>Dolphin Interconnect</td>
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<td>Fluid Operations</td>
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<td>Kadme</td>
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What is a Digital Twin?

An integrated

• multi-physics, multi-scale, probabilistic
• simulation of an as-built system, ... that uses the best available
• models,
• sensor information, and
• input data to
• mirror and predict activities/performance over the life of its corresponding physical twin

*USDOD Procurement Dictionary*
Digital Twins – Dream....
... or reality
The pains of the digital twin

• Hype and oversell: The top of the Gartner hype curve
• “Everybody” is offering digital twin.
• Concepts driven by aerospace and automotive.
• Fragmented systems, siloed perspectives and overload of data.
• Systems are difficult to configure, maintain and scale.
• Challenges in work practices, security and alignment to business.
Challenges from Industry
Wisdom

Knowledge

Information

Data

What

Why

How
Partners in understanding

How to learn valuable new things about our world
• Seeing realistic representations of things and systems
• Answering open-ended or what-if questions
• Receiving predictions or warnings
Cooperative knowledge

How to multiply our knowledge continuously
• Knowing “who to ask” for required knowledge
• Ability to “drop in” new applications onto a Twin
• Not needing to do much integration work
Information exchange

How to communicate meaning

• Breaking down boundaries and silos
• Seeing “your” world-view of the information
Data readiness

How to know what our data streams represent

• Data being semantically well-described
• Everyone contributing to this effort
• Not requiring an ivory tower
Challenges to Technology
Data readiness

How to crowd-source semantic context:
• Accelerating the data-mapping process
• Rewarding contribution
• Addressing the complexity-power balance in ontologies
Information exchange

How to form semantic context into purposeful views

• Meta-understanding the assets and data
• Targeting world-views to consumers
Cooperative knowledge

How to get applications collaborating
• Minimizing required integration work
• Forming “teams” around an asset or fleet
Partners in understanding

How to augment the physical world
• Mimicking a physical asset (Turing test?)
• Democratizing deep learning and AI
• Blurring the lines between physical and digital
Physical

Digital

Data-driven

Model-driven

MIXED

www.bdva.ey
Our Work:
Digital Twins via PI
Specific audience and goals

Grid health
Turbine performance
Power use

PI Asset Framework of today

to support process industries, asset models:
• target audiences and goals
• reduce the cost of curiosity
• build bridges across sites
PI Asset Framework of tomorrow?

to support Digital Twins, semantic models:

• span audiences and goals

• reduce the cost of integrating new applications

• build bridges across organizations and supply chains
Semantic Models

Data

Semantic Model
Semantic Models

Processes

Information

Materials

Design

Maintenance

Maintenance Plan

Requirements

Water Supply

Machines

Waste

Life Cycle

Maintenance Report
Semantic Model Features - 1

- Object oriented
- Bring together multiple worlds
  - Physical (Real)
  - Cyber (Digital)
  - Biological (Human/Cognitive)
  - ...

- Processes
- Information
- Materials
Semantic Model Features - 2

- Multi-faceted
- Different models for different user groups, e.g.:
  - Engineers
  - Finance
  - Risk Management
  - ...

Processes

Information

Materials
Semantic Model Features - 3

- Formal languages
  - Machine processible
- Wide range of management tools
  - Editing
  - Debugging
  - Integration
  - Querying
  - Browsing
- International standards
Semantic Model Features - 3

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  - Machine processible
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- International standards
Semantification is a Trend: Examples

Schema.org: is a semantic model

• annotate your documents with classes from the model
• get better search results
Semantification is a Trend:

- Examples

- Schema.org: is a semantic model
  - annotate your documents with classes from the model
  - get better search results

Google search results for 'borsch':

Classic Ukrainian Borsch Recipe - Красный Борщ - Natasha's Kitchen

https://natashaskitchen.com/classic-russian-borscht-recipe/ ★★★★★ Rating: 4.8 - 115 votes - 2 hr
Sep 26, 2010 - After several requests for my borscht recipe, here it is. Ukrainian Borscht... everyone knows what it is and many people enjoy it; Ukrainian or not. ... If you are pressed for time, shave off 1 hour by using canned beets with their juice.

How to Cook Borsch - Russian Recipe for Borshch - Master Russian

masterrussian.com/russianrecipes/borsch.htm ★★★★★
Borsch is the famous soup in many Russian families, as well as many Eastern and Central European countries. The recipes of borsch vary, but vegetables...
Semantification is a Trend: Examples

Google Knowledge Graph knows Thomas Jefferson

• that he is a person
• it knows information about him
• it knows relevant people
Semantification is a Trend

Linked Open (Semantic) Data Cloud
Semantic Digital Twins

Semantic models
• mediate data and applications
• are universal across users and applications
• already exist and can be offered via market places
Our Mid Term (Research) Goals

• Extend the PI System with semantic models
• Develop example ML tasks over semantic models
• Provide solid theoretical foundation for extensions
• Develop industrial use-cases and requirements
• Provide a demonstration with dashboards
Engaging With Us
SIRIUS’ Digital Twin Strategy

Pilot projects with Oil Companies, EPC and Vendors

Gaps and needs

Research solutions

Research and Prototyping Projects

Semantic backbone

Simulation of cloud deployment

Use of unstructured data

Support for data science workflows

Faceted user interfaces

Standardization of semantics & interfaces

Use of streaming data from sensors

Hybrid analytics
Contact Information

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