Digital Twins as a Platform For Artificial Intelligence in the Petroleum Supply Chain

David Cameron, Arild Waaler
SIRIUS Centre, University of Oslo
Mara Abel,
UFRGS Instituto de Informática
The SIRIUS Centre

- Eight years’ financing from RCN
- 14 Industrial Partners (11 in 2017)
- 5 Leading Academic Institutions
- Centre for Research-Based Innovation
- Funding for 20 Ph.D. students
- Innovation through prototypes and pilots
- 50 affiliated researchers
# Research programs build a foundation for ...

<table>
<thead>
<tr>
<th>Analysis of Complex Systems</th>
<th>Ontology Engineering</th>
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<tbody>
<tr>
<td>Semantic Integration</td>
<td>Data Science</td>
</tr>
<tr>
<td>Scalable Computing</td>
<td>Industrial Digital Transformation</td>
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... Beacons addressing industry challenges

<table>
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<tr>
<th>Geological Assistant</th>
<th>Integrated Digital Planning</th>
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<tr>
<td>Subsurface Data Access &amp; Analytics</td>
<td>Digital Twins</td>
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<td>Digital Field &amp; Reservoir Management</td>
<td>Digital Field Development</td>
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<td>Personalized Medicine</td>
<td>Environmental Applications</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.”

www.dau.mil/glossary/pages/3386.aspx
A digital twin success story: on-line flow assurance
How a simulation digital twin works

- Tracking Model
  - Tracks status of system
  - Data collection and cleaning
  - Boundary conditions
  - Tuning measurements

- Offline Model
  - Analyzes status of plant

- Look-ahead Model
  - Predicts status of plant
  - Snapshot of plant state and configuration

Data for decisions
A conceptual framework for twins

Users with diverse roles and interests

Best estimate of system state

Driver for artificial intelligence!

Glorified SCADA

3D viewer

Training Simulator

Simulations and Analyses

Measurements

Asset Configuration (LCI)
Current and planned twin applications

• Established practice
  • Flow assurance twins
  • High-quality visualization of operational data with 3-D model of facility

• Commercial but novel
  • On-line top-side operations simulators for prediction and data reconciliation
  • Structural and other special-purpose twins

• Future
  • Whole field twin: reservoir, flow assurance and top-side in interaction
  • Integrated twin along asset lifecycle and product lifecycle
Today’s twins are bogged down in virtual paper!

Demands
- from regulators
- from company
- from partners

Operating procedures
- Operations and optimization

Requirements
- Design rules
- Design
- Design basis
- Construction and commissioning
- As built
- Facility

Digital twin
A vision for digital twins in 2024
What would this mean for a complex offshore field (such as Libra)?

Business models, security and confidentiality

Work practices

Scope

Usability

Integration

Maintenance

Computational power: edge and cloud

Neutral data format

Uncertainty, validation and data science
PeTWIN: Whole-field digital twins for production optimization and management

Petromaks/FINEP Project: 2020-2023
28M kr project sponsored by Research Council of Norway, FINEP, Equinor, Shell and Petrobras
The problems to be addressed

- Real time data
- Production rates

Prediction Models + Production plant data

Simulation results

Feed back
Production adjustments

All information is time labelled

- Seismic logs
- Well logs
- Well tests
- Sensor measures
- Equipment reports
- Incident reports

Dynamic data

Static data (but evolving)

Life cycle information

Simulation Information

Semantic Support

- Domain Ontology
- Technical vocabulary
- Relevant relations
- User profiles
- Fields of interest
- Facets

Prediction (medium-term application of data)

Tracking and Monitoring (Short-term Application of data)
## Impact

<table>
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<tr>
<th>From...</th>
<th>To...</th>
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<tbody>
<tr>
<td>Unclear and hyped</td>
<td>Robust, research-based best practice</td>
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<tr>
<td>Point-to-point, ad-hoc integration</td>
<td>Model-driven integration</td>
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<tr>
<td>Multiple applications in silos</td>
<td>Integrated applications</td>
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<tr>
<td>Vendor lock-in</td>
<td>Standards-based interoperability</td>
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<tr>
<td>Ad-hoc and manual change control</td>
<td>Lifecycle model for change control</td>
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<tr>
<td>Data science and machine learning is hard to scale</td>
<td>DSML is automated and supported by models</td>
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<tr>
<td>Semantic models are hard to build</td>
<td>Engineers and geologists can build models</td>
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<tr>
<td>Separate user interfaces</td>
<td>Standard, semantic user interfaces</td>
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<tr>
<td>Integration in a data lake</td>
<td>Data is kept where it is most useful</td>
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<tr>
<td>On-site deployment</td>
<td>Best possible deployment</td>
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<tr>
<td>Small-scale academic projects</td>
<td>Realistic oil and gas systems.</td>
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Sandstone A is an instance of Sandstone, which is constituted of Rock. Geologically, Upper Jurassic Sand is an instance of Geological Unit, which has a Geological Age. Structural cross section and distribution of hydrocarbons through Troll Field (Johnsen et al., 1995).
What we will deliver

• Common semantic models of subsurface, facilities and lifecycle that can be used for data integration and governance.

• Prototype tools for:
  • Integrating and maintaining digital twins
  • Building and maintaining semantic models
  • Visualizing and analysing data in the twin.

• Demonstration and minimum viable product on company examples.

• The book about oil and gas digital twins.
Acknowledgements

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Brazilian Agencies
I SEMINÁRIO DE
INTELIGÊNCIA ARTIFICIAL
APLICADA À INDÚSTRIA
DO PETRÓLEO