Concept for an Open-Source Drilling Simulator With Focus on Education and Research

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Outline

- Introduction
- Current state of drilling simulation
- So what is missing? / Proposed solution
- Implementation details
- Conclusions and future work

Introduction – Who are we?

Mission

- Support and enable science by applying appropriate technologies, developing innovative solutions, and providing reliable services
- Planning, implementation and operation of IT infrastructures together with and for our customers

Central responsibilities

- Modern and secure IT infrastructure
- IT support for excellent research
- In-house research for innovative IT-Services

Supra-regional tasks

- National High Performance Computing Center
- National HPC Center of the DLR
- AI service center for sensitive and critical infrastructures
- Data center in four NFDI consortia
- Host for DARIAH-EU, German National Library, GFBio, NUM CODEX, MWS, WirLernenOnline, etc.
- Cloud operator, including AcademicCloud for universities in Lower Saxony

Introduction – Drilling Simulation

Important for:

- Education
  - Deep understanding of drilling process for drilling crews
  - Motivation of students to deeper explore the field
- Industry
  - Optimally planned drilling projects reduce costs and risks
  - Cost effective training of management and rig crews
- Research
  - Detailed simulations provide base for new innovative solutions
  - Complement and enhance understanding of experimental investigations

Existing Drilling Simulators

Commercial:

- 3t Drilling Systems
- NOV Portable Simulators
- PayZone Drilling Simulator

Freemium:

- OpenLab Drilling

Open Source:

- Open Source Drilling Community
- Texas A&M Github Repository

Existing Data Sources

- BGR
  - KTB
  - Genesys
- Equinor
  - Many datasets
- Inhouse data

Existing Models

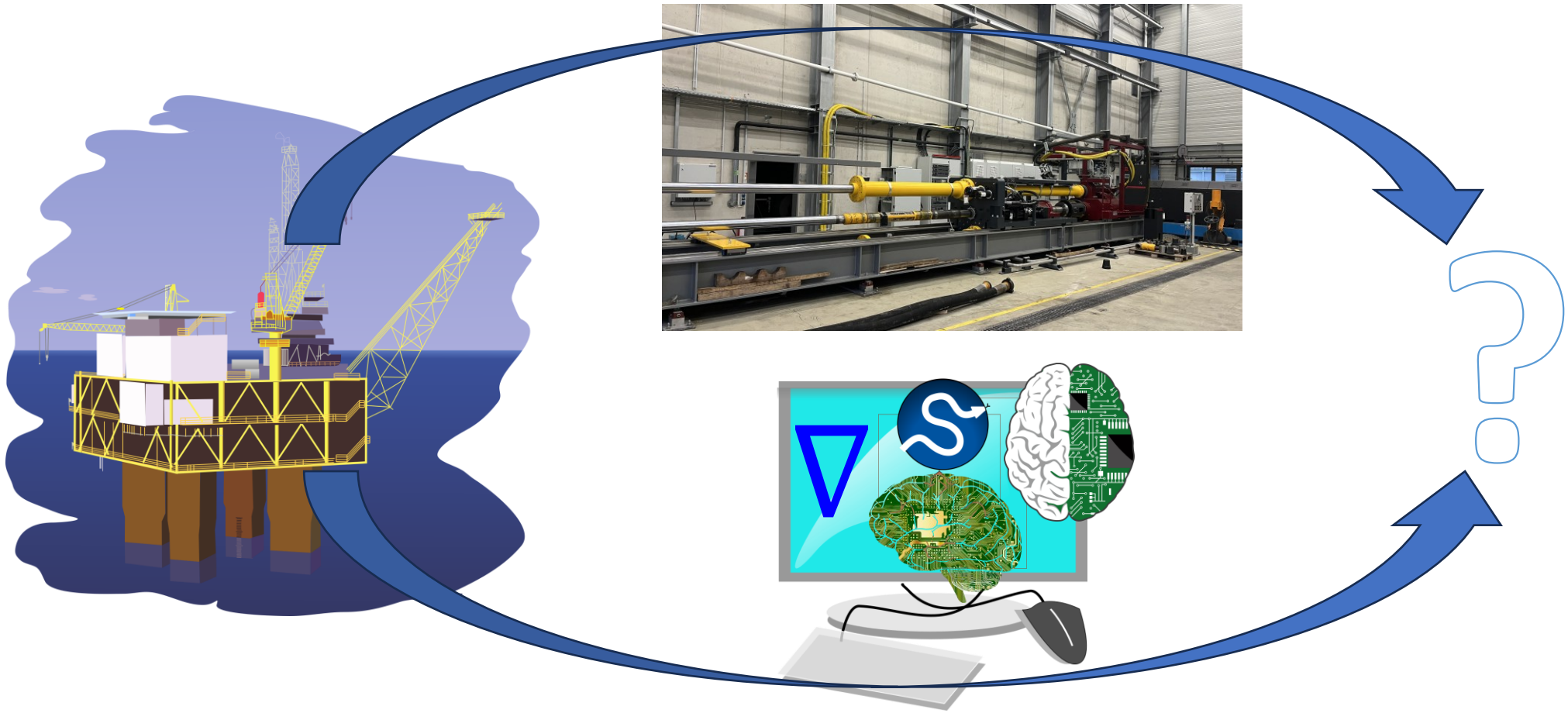
Classical Models

- Temperature models
- ROP literature models
- TOB literature models
- Combined time series TOB and ROP model
- Drift-Flux Cuttings Transport model
- WOB model
- Drillstring dynamics models
- Time series flow models
- Torque & Drag model

Machine Learning Models

- ROP models
  - Symbolic regression
  - Scikit-Learn based ML models
- TOB models
  - Scikit-Learn based ML models
- WOB model

So what is missing?



Education and Research in Drilling Engineering

- Reliant on commercial simulators with no access to underlying source code

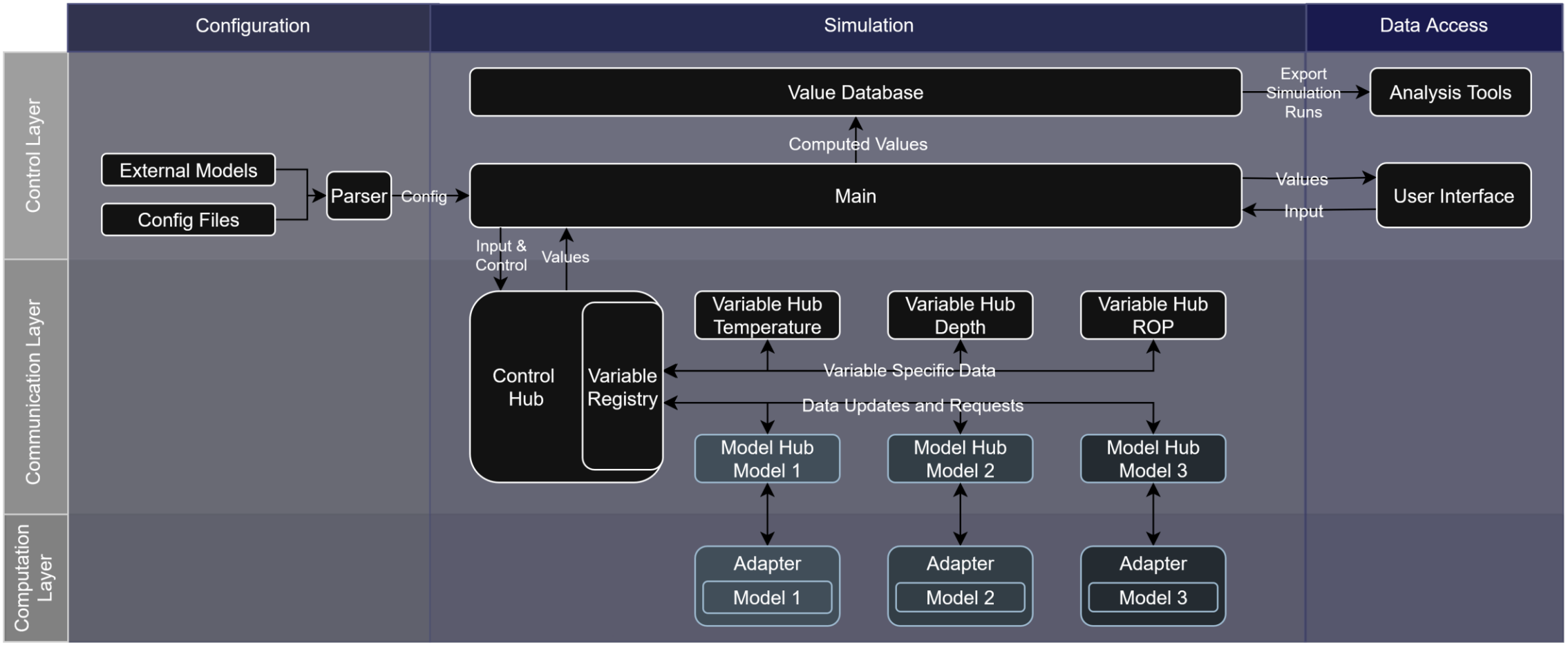
→Limited understanding for both students and researchers of the detailed behaviour of the implementation

- Implementation languages, e.g. C++, C# not easy understandable by drilling people
- Limited possibility of modifications restricted by API access to commercial simulators

Proposed Solution

- Implementation as an Open-Source Simulator accessible to everyone
- Published under AGPL for maximum openness
- Potential for collaborative development
- Possibility to validate used algorithms, replace models and adjust simulation processes
- Implementation using Python as easy entry boundary and support for machine learning
- Adapters to other languages and interfaces, e.g. OPC-UA, FMI, grpc

Architecture



Configuration-Example

```yaml
TEMPERATURE_0D:
  name: "TEMPERATURE"
  desc: "Temperature at the deepest point of the borehole."
  interpolator: "COSINE"
  value:
    type: "float"
    unit: "°C"
    initial_vals:
      0: 21
```

```yaml
ROP_MODEL:
  name: "ROP"
  desc: "Oversimplified model for ROP."
  adapter_type: "SIMPLE_PY"
  definition:
    type: "SIMULATION.CLASSMETHOD"
    location: "models.models.OversimplifiedROPModel"
    target: "get"
    static: true
    input:
      - variable: "ROCK_TYPE"
        datatype: "str"
    output:
      - variable: "ROP"
        unit: "m/h"
        datatype: "float"
```

Highlighted Features

- Models from supported sources connectable using .yaml interface definitions with no additional coding needed
- Simulation customization possible using configuration files in yaml format
  - Including definition of additional variables and interpolation methods
  - In the future configuration files
    - Connection to supported databases
    - Customization of interfaces
- Further customization possible by modular code design beyond limits of yaml configuration, each component with defined interface and replacable independently if necessary

Implementation Status

Current Implementation Status:

- Simulation run startable using CLI tool, with automatic connection to simple externally defined python models using configuration files
- Each model executed asynchronously in an independent process, with their computed values available to other models through a central variable registry
- Simulation results accessible through an output file with timeseries data
- Working prototype of graphical user interface with live data

Upcoming Features:

- Integration of first real open-source models
- Extensive user and developer documentation

Conclusion and Future Work

- Free and open-source framework for research and teaching
- First working prototype implemented and successfully executes simulations using oversimplified models
- Already including concurrent execution to prevent performance bottlenecks
- Next steps: Integration of existing models and export of simulation data

Spread the word for collaboration!