Models Meet Data Challenges to Create Virtual Entities for Digital Twins

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Agenda

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- Introduction to Digital Twins (DT)
- Non-Technical Challenges in DT development
- Technical Challenges in DT development
- Road Ahead
- Conclusion & Future Work

Introduction on Digital Twins

- Combination of Software and hardware
- Scope is limited to engineered artifacts
- Different digital twin definitions since the time of its inception



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Digital Twin 5D Model



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Non-Technical Challenges

Communication among multi-domain stakeholders leading to ambiguity.



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Non-Technical Challenges

• A multitude of definitions of Digital Twin leading to differences in understanding.



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Challenges in DT Static Consistency

Necessity of model management framework that can:

- Detect inconsistencies among cross-domain models.
- Integrate seamlessly into existing tools.
- Work in multi-platform environment.
- Operate automatically and in real-time.





Road ahead – DT Static Consistency

- Research on methodologies for establishing communication across engineering domains.
- Research and develop generic tooling for cross-domain multi-platform model management capable of tracking and signaling consistency violations.



Challenges in DT Orchestration

Three challenges identified:

- Control and data flow: Challenge is related to the execution of each model and how to integrate them to reproduce the intended behavior.
- Framework: What integration tool can be used for heterogeneous models in order to reduce integration complexity?
- Communication: Heterogeneous models have different semantics and syntax; thus, what are the requirements for interfaces & encapsulation for DTs?





Road ahead – DT Orchestration

Study on DT requirements and properties on the execution of its models can yield:

- A DSL to capture the control and data flow by capturing its concepts and features.
- The design of an appropriate framework for integration, reducing complexity & increasing maintainability.
- Clearer understanding on model's communication needs, which aids the analysis & design of suitable technologies.



Challenges in DT Dynamic Consistency

- Undesirable dynamic behavior or performance issues (reachability, timing, ...) in DT arises due to:
 - Many time critical, stochastic interactions within DT
 - Variable model execution times
- Affects the overall functioning of the DT.
- One performance issue could also lead to another.
- Evolution of models and interactions could further contribute to this problem.

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Road ahead – DT Dynamic Consistency

- Research on methodologies for validating the overall DT and the corresponding tooling required.
- Research on the different set of properties to be validated in the DT.
- Model Checking is the technique being explored under the current setting.

Conclusion and Next Steps

- Identified different challenges in the development of Virtual Entities
- Identified future research topics to overcome these challenges
- Also: started interviews on DTs with different stakeholders from academia and industry

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