A Digital Engineering Factory for Students

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Research Objectives:

To enable students to work together in a digital environment that:

- provides access to multiple tools required across multiple engineering courses,
- supports collaboration and configuration management with a robust CI/CD pipeline,
- Allows students to work on an end-to-end project and observe effects of decisions
- Leverages Semantic Web Technologies (SWTs) to support academic practice (e.g., collaboration, grading, review)

To assess the benefits of this digital approach to teaching.

CHALLENGES

To achieve the research objective, we need to:

- understand the **data models** underlying common domain languages,
- develop a network of Systems and Software **Engineering Ontologies** [1], covering multiple engineering disciplines, that is based on a suitable Top-Level Ontology (i.e., BFO [2]),
- utilise **Hub-and-Spoke** approach to integrate data - we have selected the Violet tool [3],
- **host** on a local server at the University of Arizona,
- consider **authorisation, privacy**, etc.,
- ensure that course content can be **integrated effectively** into the 'Digital Engineering Factory'.

APPROACH

1. Build a **tool-suite** that students can use for:
   - Project management
   - Requirements management
   - System and Software development
   - Integration and test
2. **Integrate** data from multiple tools
   - Adopt the Violet tool
   - Establish CI/CD pipeline based on Git
3. Build a supporting **ontology stack**
   - And technologies (validation, querying)
4. Generate a project **repository** within the University
   - Collect all student models, simulations, etc.
   - Provide starting point for future students
   - Research patterns across project repositories

DIGITAL ENGINEERING FACTORY

Key Features:

Tool Suite (multiple tools hosted locally)

- support 25 unique users (and scale to 350 users).
- support 5 students accessing tools simultaneously.

Dashboards

- Supported by default and custom SPARQL queries
- containing project summary (e.g. requirement status).

University of Arizona Ontology Stack (OML, RDF).

- reason (SWRL), query (SPARQL), validate (SHACL).

Curriculum Information

- to support tool selection and provide project info.

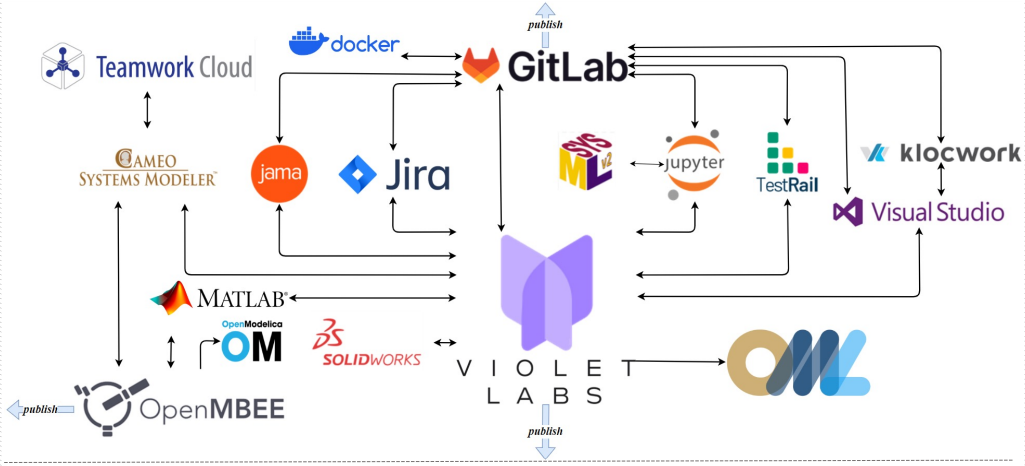
Courses (selection of possible integrations):

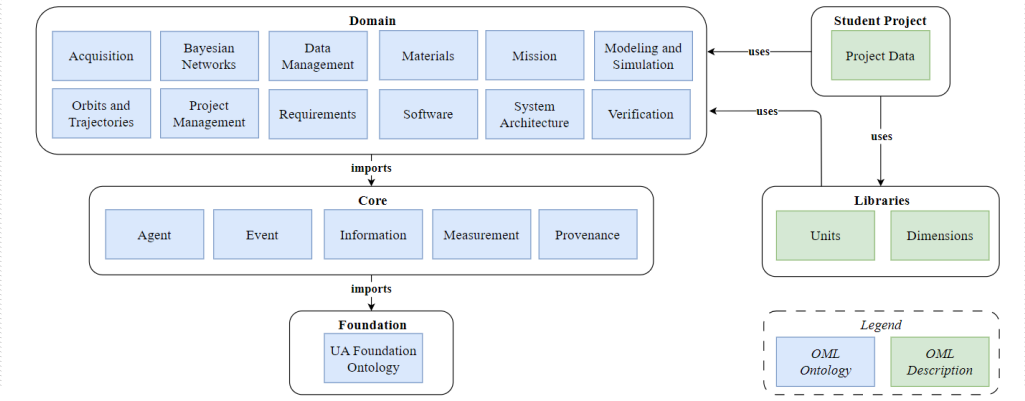
Systems and Industrial Engineering (SIE)

- SIE 458 – Model-Based Systems Engineering
- OpenMBEE [4] – SysML-analysis loop
- OpenMBEE – View generation

Software Engineering (SFWE) Courses

- SFWE 101 – Introduction to Software Engineering
- SFWE 301 – Software Requirements Analysis & Test
- SFWE 401 – Software Assurance and Security
- SFWE 402 – Software DevSecOps
- SFWE-403 – Software Project Management





EXPECTED BENEFITS

Students generate data to be used in other courses.

e.g. requirements generated by students in one class are used by other students in their design class.

Potential **benefits** include:

- Over multiple courses, students see a complete **end-to-end** process,
- Students see the **consequences** of their decisions downstream,
- Students gain experience working **collaboratively** in a digital environment,
- Students can **evaluate** other's work more effectively.

Validation:

- Ontologies support validation rules that can aid automatic data checking
- Students can check their work before submission
- Instructors can have validation sets to aid grading

Querying

- Default queries to generate view-specific dashboards
- Custom query interface to support users

CONCLUSIONS

The 'Digital Engineering Factory' supports engineering students:

- **Tool Suite** – with connections established at the data-level via Violet using REST APIs and a CI/CD pipeline.
- **End-to-End –** over multiple courses, students complete a full end-to-end process.
- **Collaborative Engineering** – students gain experience in a collaborative environment.
- **Semantic Technologies** – enabled by a generated graph database and OML engineering ontologies.
- **Student Project Repository** – published student work will be collected, stored and used in future work.

REFERENCES

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[3]: Violet Labs, "Violet Labs Tool," , 2023. Available at https://violetlabs.com/, Date Accessed: 2023-05-20.

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