CDL-Flex Industry Newsletter

October/November 2013

Editorial

Dear reader,

making engineering collaboration more effective and efficient in a heterogeneous software tool landscape is an ongoing issue for software solution providers and users.

At the upcoming **SPS/IPC/Drives 2013 exhibition for electric automation technology** experts from the Christian Doppler research laboratory CDL-Flex at the Vienna University of Technology will present and discuss applications for industry partners based on the Automation Service Bus® (ASB) for the integration of software tools, data, and engineering processes and added-value components, e.g., semantic search across heterogeneous engineering models.

- **Quality-assured and traceable tool chains** for distributed engineering projects of industrial plants.
- **Semantic search** across heterogeneous engineering models.
- **Integrated simulations** of industrial processes (SCADA & Simulation)

At the SPS/IPC/Drives 2013 exhibition, scheduled for November 26.-28 in Nuremberg, Germany, you can find us at the **TU Wien booth in hall 4-575**, see details in the section on upcoming events.

In this edition of the newsletter you will find results from CDL-Flex research and evaluation:

- Lessons learned from Industry Use Cases: **Semantic Search** Across **Engineering Models**
- Research Use Case: **Semantic Dropbox** for user-friendly and quality-controlled tool chains in Automation Systems Engineering
- Inside View: **Ontologies in Multi-Disciplinary Engineering Environments** to enable an integrated view on heterogeneous Engineering Models.
- New Research Results: **Application of Bond Graphs to model complex environments** for integrated simulations.
- Consider taking part in the **upcoming events** with experts from the CDL-Flex.

We hope you enjoy the articles and find food for thought on potential improvements and new solutions in your environment. On request we will be happy to provide you with the cited papers. We are looking forward to discuss your suggestions on issues for research and development to foster alternative solutions for better software data, model, and tool integration in engineering environments.

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SEMANTIC SEARCH ACROSS ENGINEERING MODELS

Software and systems engineering projects require the cooperation of several engineering disciplines, such as electrical, mechanical, and software engineering. For project or engineering plant progress exploration and analysis there is the need for mechanisms enabling the execution of queries over such heterogeneous environments.

The Engineering Knowledge Base (EKB) [1], a component of the Automation Service Bus (ASB), enables a mapping of local tool-specific engineering concepts to a common project-wide engineering concepts, and thus facilitates the seamless integration of data coming from miscellaneous engineering tools [2].

However, the constellation of deployed tools forms a complex structure of relations between heterogeneous tool data models. Figure 1 shows a relevant collection of basic models in automation systems engineering, while Figure 2 depicts the complexity behind each of the models.

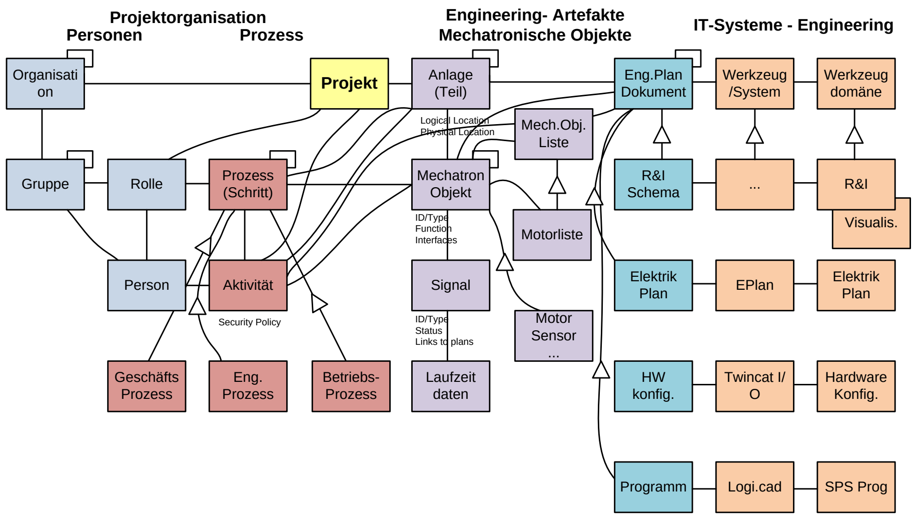

Fig. 1: Simple Structuring of Project-relevant Models.

From an integrated point of view, at project level it is, therefore, hard for the project manager and engineers to formulate precise queries and to retrieve project-relevant information for effective decision making. A search process using semantic technologies demonstrates how the effort for formulating queries with effective tool support may be minimized. In contrast to traditional approaches, in which the project participant is responsible to query each of the data sources of every affected model of a query and aggregate the information to provide the final results, the semantically enhanced search lets the project participant focus on the formulation of the query while execution and aggregation is conducted automatically in the background.

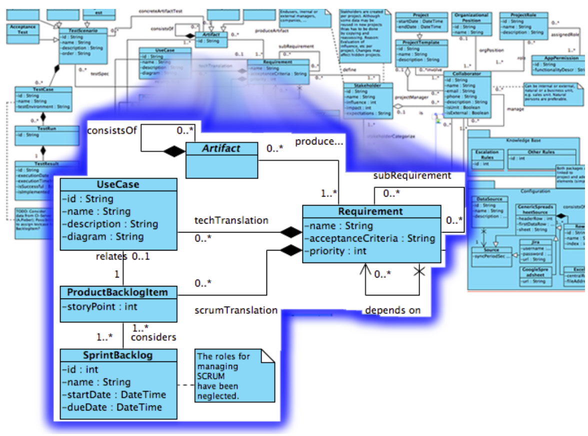

Fig. 2: Examples of the Complexity of Domain-Specific Models [3].

The approach supports projects participants by enabling the context- and role-specific formulation of queries. The role is defined in the EKB and instantiated whenever the project member logs into the ASB. Similarly, the context defines the main components (in the perspective of a mechatronical object) the user is responsible for. The EKB enables the approach to guide the formulation of a query by considering the tasks and the responsibilities of the project member, and thus being able to suggest queries which may provide the most valuable information from the project member's point of view. There are several ways of a guided query formulation, like:

- a preselected set of queries the project participant can choose from;
- a set of query templates with parameters the participant can choose from;
- a weighted list of queries, e.g., depending on the number of changes a mechatronical object is undergoing in a specific project phase;
- an engineering model navigator tool that enables the user to navigate through the structure of model relations and assemble the query along the selected models.

The exemplary UC focuses on the IEC 61131-3 Programming Model for which the data is provided via TC6 XML files. Queries engineers may for instance ask are:

- In which Resources is a given Function Block Type instantiated?
- Which Global Variable Declarations are not referenced by any External Variable Declaration?
- Which referencing Global- or External Variable Declarations have no matching Type Names?
- Which variables are really connected to a physical port in the hardware configuration of the plant?

The approach provides the user with the capability to define views on and thus monitor the relevant parts of mechatronical objects and the progress of the project.

References

[1] Moser, T., Biffl, S., Sunindyo, W. D., and Winkler, D.: Integrating Production Automation Expert Knowledge Across Engineering Domains. Int. Journal of Distributed Systems and Technologies (IJDST), Special Issue, pp.1–15, 2010.

[2] Winkler, D., Moser, T., Mordinyi, R., Sunindyo, W.D., and Biffl, S.: Engineering Object Change Management Process Observation in Distributed Automation Systems Projects. Proc. of the 18th European System & Software Process Improvement and Innovation (EuroSPI) Conference, 2011.

[3] Grünwald, A., Winkler, D., Serral, E., and Biffl, S.: Semantic Technologies for More Efficient Model-driven Development. WiP Proc. of the 39th Euromicro Conference on Software Engineering and Advanced Applications (SEAA), 2013.

(Richard Mordinyi)

RESEARCH USE CASE

SEMANTIC DROPBOX

In software and systems engineering projects there is a multitude of models used by engineers, management, and customers, which are often only implicitly linked by the project stakeholders and fragile supported by tools. Therefore, the effort and user friendliness for the quality-controlled propagation of changes to engineering plans across tool chains in heterogeneous software data models should be improved. The *Semantic Dropbox* provides traceable and automated propagation of changes using *the Automation Service Bus® (ASB)* and helps the project team to achieve this goal.

The *Semantic Dropbox* enables project

participants to create work space folders, and share and synchronize files in these folders with other project participants, similar to the *Dropbox*[1] concept (see Figure 3). In addition, the *Semantic Dropbox* transforms data between local representations of common concepts, so each project participant sees the representations of common concepts in his local representation format.

The *Semantic Dropbox* approach provides

- eliciting common concepts from domain experts on important models, links, and queries;
- linking the common concepts explicitly to local representations to enable automated data sensors and tool chains;
- automatically transforming data between the local representations and the common concepts.

Common concepts enable the analysis of data exchanges on content and process level. Figure 3 shows a *Semantic Dropbox* example with three partners A, B, and C. Each partner has a *Semantic Dropbox* folder that contains sub-folders for sharing files with project partners (similar to work spaces): a folder can represent work items in a specific process step and/or for work teams.

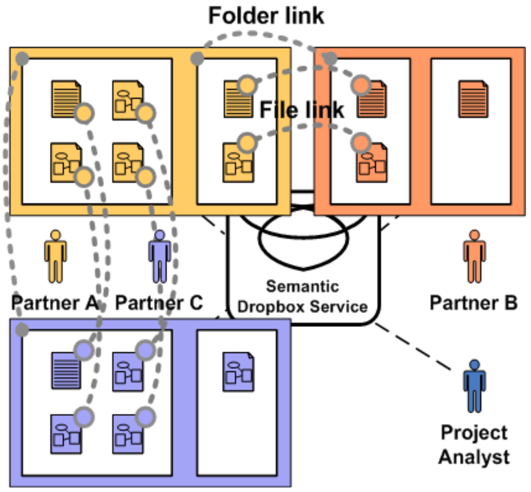

Fig. 3: Semantic Dropbox Environment.

Basically *Semantic Dropbox* processes include (a) *basic project configuration*, (b) *local user configuration* of folders and files, and (c) the *use of the Semantic Dropbox* for data synchronization and transformation.

Figure 4 illustrates a basic example where the common concept signal can be seen locally as an electrical plan signal or as a hardware configuration signal (electrical engineer) and as a software variable from the software perspective (software engineer). Note in this example that the electrical engineer uses a CSV data format as an input for the Semantic Dropbox and the software engineer applies an XML data structure as input for data synchronization. Data are linked and synchronized via the Semantic Dropbox applying common project-level concepts. Synchronized data can be analyzed and visualized and used for project monitoring and control to enable a comprehensive view on the overall engineering project, e.g., by using an Engineering Cockpit [4].

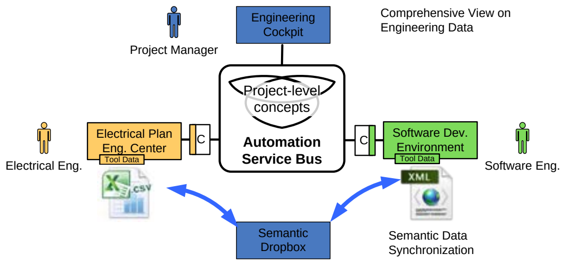

Fig. 4: Tool chain via a Semantic Dropbox.

Cost-benefit considerations. Domain experts can produce traceable and secure tool chains easily (in a few days instead of weeks). Practitioners can propagate changes to engineering objects efficiently (in seconds instead of minutes). Quality managers can evaluate activities on engineering objects (e.g., changes to library code blocks) automatically, even across several projects.

References

[4] Moser T., Mordinyi R., Winkler D., Biffl S.: Engineering Project Management using the Engineering Cockpit: A collaboration platform for project managers and engineers", 9th International Conference on Industrial Informatics (INDIN), Lisbon, Portugal, 2011.

(Stefan Biffl, Dietmar Winkler)

[1] Dropbox: http://www.dropbox.com, Dropbox and the Dropbox logo are trademarks of Dropbox, Inc.

ONTOLOGIES IN MULTI-DISCIPLINARY ENGINEERING ENVIRONMENTS

Modern industrial automation systems engineering (ASE) projects are large and complex, and often involve several heterogeneous engineering disciplines [5] as shown in Figure 5. Semantic integration, i.e., the explicit and machine-understandable description of engineering knowledge, allows data integration across tool and domain boundaries, as well as automated Quality Assurance (QA) techniques to support project stakeholder for retrieving relevant information and speed up decision making process.

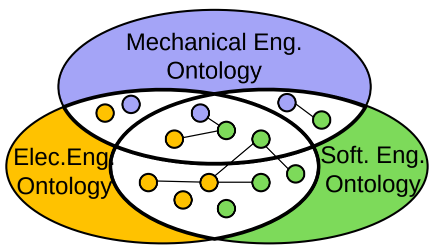

Fig. 5: Multidisciplinary Engineering Environment in ASE.

Ontologies currently emerged as one of the most popular solution for semantic integration, and we identify them as the main component to enable semantic integration in the context of multi-disciplinary engineering environments (MDEE). Key capabilities of ontology in the context of MDEE are:

- **Data integration**. This capability enables integrated view of heterogeneous engineering models via mapping and transformation to support project stakeholders in retrieving relevant information.
- **Interchangeable format**. Ontology community provides a wide range of tool supports for data import and export from various important data formats, e.g., spreadsheet, XML and database.
- **Inference and reasoning**. These capabilities provide users with enriched information, which derived automatically from the original data.

In order to show the benefits of ontology in context of MDEE, we set up an exemplary UC that is focused on IEC 61131-3 Programming Model as previously mentioned in the “Industry Use Case: Semantic Search Across Engineering Models” article.

Within the UC, we show that ontology could support ASE project stakeholders to retrieve relevant information from projects. Figure 6 shows the ontology processes flow.

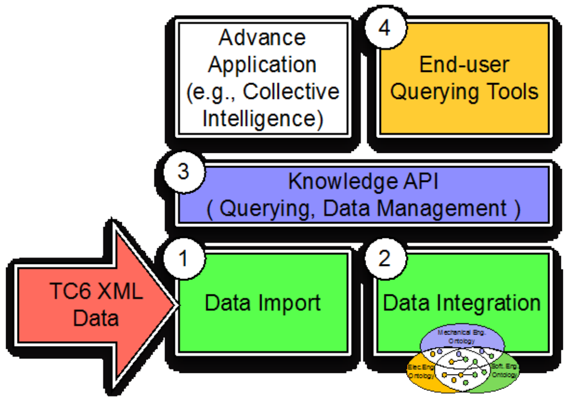

Fig. 6: Ontology process flow in the showcase

The ontology processes within the exemplary UC consist of following steps

1. **Automatic data import.** Data import from the IEC 61131-3 in the provided TC6 XML format file into ontology.
2. **Flexible data integration.** Definition of common data model and data enhancement to answer most of relevant queries related to IEC 61131-3 model.
3. **Knowledge API layer.** To enable efficient data querying from users, we provide API based on widely used Apache Jena[2].
4. **End-user querying tools.** Implementation of siple querying tools to show that the ontology could answer queries accurately.

[2] Appache Jena: http://jena.apache.org

Building on the exemplary UC processes, we are considering to provide more advance application e.g., Collective Intelligence and Quality Management.

References

[5] Moser, T., Mordinyi, R., Winkler, D., Melik-Merkumians, M., & Biffl, S.: Efficient automation systems engineering process support based on semantic integration of engineering knowledge. Proc. of ETFA, 2011.

(Fajar J. Ekaputra)

NEW RESEARCH RESULTS

APPLICATION OF BOND GRAPHS TO MODEL COMPLEX ENVIRONMENTS FOR INTEGRATED SIMULATIONS.

Industrial automation systems are becoming more complex and sophisticated. That is why their control and optimization are hard tasks. *Simulation models* are playing an important role for various scenarios in industrial system design. They can be used to train and to test human operators, to fine-tune control systems, or for advanced process control.

One of the main obstacles for using simulation models is a *time-consuming and error-prone engineering phase*, which is based on manual work. The *main goal* of this article is to present a semi-automated method for creating simulation models for large-scale industrial systems. The presented methodology assumes that systems consist of *pre-defined atomic components* (such as pumps, pipes, and tanks) and it utilizes the Bond Graph theory to assemble a model from the components.

The *bond graph method* is an engineering approach for describing physical systems and creating simulation models. Bond graphs are based on three analogies[6][7]:

1. Signal analogies
2. Component analogies
3. Connection analogies

The basic idea of the *signal analogy* is expressing power transport between components. Bond graphs introduce generic signals “flow” and “effort”, whose product is power. In electric systems, effort is electrical voltage and flow is electrical current. In hydraulic systems, effort is hydrodynamic pressure and flow is liquid flow. The product of these variables (i.e., power) can be considered as “the universal currency of physical systems” [7].

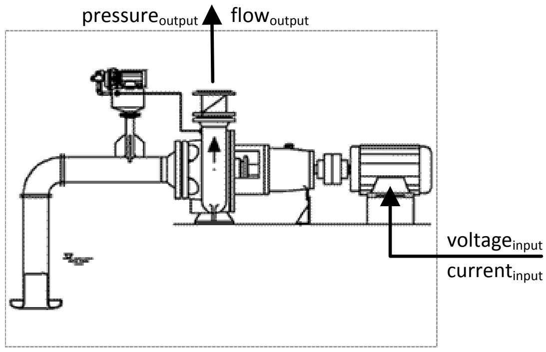

Fig. 7: Each device has input and output pairs of effort and flow variables.

Component analogies introduce generic components such as “resistor”, “capacitor”, “inductor”, “source of effort”, or “source of flow”. For example, the resistor in a hydraulic system is a pipe, in a mechanical system it is a damper. *Connection analogies* introduce a “0-junction” and a “1-junction” in order to model parallel and serial connections.

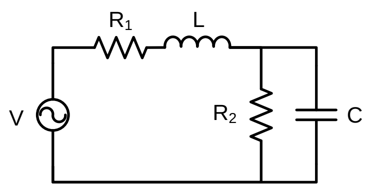

Fig. 8: An exemplary electrical circuit.

Bond graphs are *graphical notations* of components, connections, and power flows. To illustrate how a bond graph looks like, we selected an exemplary electrical circuit, which is depicted in Figure 7 and Figure 8. For this electrical circuit, the adequate bond graph is shown in Figure 9. It includes the following system components: a source of effort (*SE*) corresponding to a voltage source in a real system, two resistors (R_1, R_2), a capacitor (*C*), and an inductor (*I*). These components are interconnected via 1-junctions and 0-junctions, which are abstractions of serial and parallel connections in a physical world. Furthermore, the bond graph includes directed power flows, denoted by semi-arrows. The important issue of bond graphs is a causality that supports determining which of the variables effort and flow is the input variable and which is the output one in case of each bond.

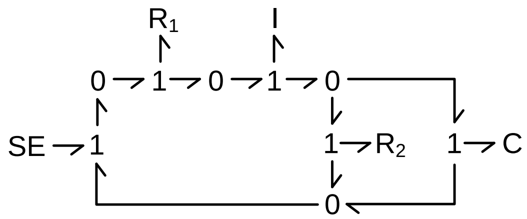

Fig. 9: Bond graph for the electrical circuit, incl. components, junctions, and directed power flows and voltage (v) as output, or vice-versa.

Bond graphs can support the following engineering tasks:

1. Automated or semi-automated design of simulation models using simulation component libraries;
2. Design of interfaces for integration;
3. Support of simulation model design also in cases of unavailable simulation libraries.

In more details, we would like to use the ability of bond graphs to resolve which variables are input ones and which are output ones, both on the level of simulation components and on the level of the whole simulation modules in coupled simulations.

The main innovation in our approach is the generic support of diverse implementations of simulation components, as depicted in Figure 10. These block versions are selected according to their input and output signals, using the bond graph theory.

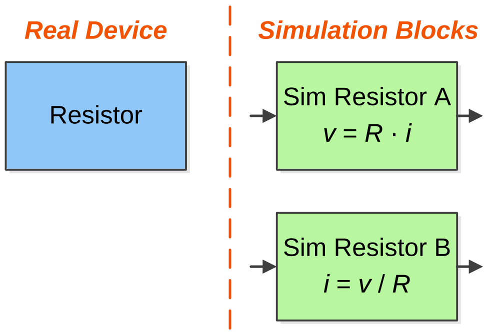

Fig. 10: Problem of 1:n mapping between real devices and simulation blocks. For example, a real device resistor can be simulated by either a resistor approximation having electrical current (i) as input.

The application of the proposed method enables to *assemble the structure of the simulation model automatically*. Handling block parameters poses a future work topic.

References

[6] Beez, S., Fay, A., Thornhill, N.: Automatic Generation of Bond Graph Models of Process Plants. In: Proc. 13th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), Hamburg, 2008.

[7] Gawthrop, P., Bevan, G.: Bond-Graph Modeling. IEEE Control Systems Magazine, vol. 27, no. 2, p. 24 – 45, April 2007.

(Petr Novak)

UPCOMING EVENTS & ADDITIONAL INFORMATION

SPS/IPC/DRIVES 2013 TOOLS FAIR

- November 26.-28, 2013
- Nuremberg, Germany
- www.mesago.de/de/SPS/home.htm

Experts from CDL-Flex will be present also this year on the "SPS/IPC/Drives" from November 26 to 28 in Nuremberg, Germany. At the booth of the **Technische Universität Wien (hall 4/booth 575)** you get insight into the latest results from applied research, which have been worked out in cooperation with industry partners. Also, the CDL-Flex industry partner **logi.cals** will show development results in **hall 11/booth 310.** Come with a Free Ticket to the SPS/IPC/Drives and visit us for a Viennese "Apfelstrudel"! For more information, please contact Dietmar Winkler at dietmar.winkler@tuwien.ac.at.

IECON 2013 (39th Annual Conference of the IEEE Industrial Electronics Society)

- November 10.-13, 2013
- Vienna, Austria
- http://www.iecon2013.org/

Experts from the CDL-Flex have been organizing the Special Session on "Engineering Tool Integration for Mechatronical Engineering and Industrial Automation System Development" (ETAS).

Software Quality Days 2014 (SWQD)

- January 14.-16, 2014
- Vienna, Austria
- http://software-quality-days.com/

Experts from CDL-Flex have been organizing the *scientific program* of one of the largest events on software quality and process improvement, the Software Quality Days in Vienna. Quality – investment into the future is the motto of the upcoming event with more than 60 presentations, 30 industry demonstrations, and over 300 participants.

READER'S PICKS

- M. Barth, S. Biffl, Draht R., Fay A., D. Winkler: "Bewertung der Offenheit von Engineering Tools", Open Automation no 4, 2013.
- S. Biffl, R. Mordinyi, and T. Moser: „Anforderungsanalyse für das integrierte Engineering - Mechanismen und Bedarfe aus der Praxis" *atp edition – Automatisierungstechnische Praxis*, vol. 5, pp. 28-35, 2012 (*winner of the best paper atp award in 2013*).
- S. Biffl: „Weg von den Software-Werkzeuginseln", Konstruktion & Engineering, KE next, no 06, 2013.
- S. Biffl, T. Moser, and R. Mordinyi, "Automation Service Bus löst Software-Problematik," *Computer & AUTOMATION*, no. 6, 2012.

SURVEY ON ENGINEERING PROCESS IMPROVEMENT NEEDS

In order to better understand the needs of practitioners for better software data, model, and tool integration for the engineering of industrial plants, researchers at the institute for Software Technology at the Vienna University of Technology and at the Otto-von-Guericke University Magdeburg conduct a survey with industrial experts.

Goals are data collection and analysis on the current situation in industrial practice and needs for better integration of software tools. If you are willing to discuss your view on engineering data and tool integration needs and approaches, please drop us a short mail message to stefan.biffl@tuwien.ac.at

CDL-FLEX RESULTS ONLINE

Do not miss the latest **presentations, use cases, videos, and screen casts** of implemented prototypes on the CDL-Flex Website at http://cdl.ifs.tuwien.ac.at