PROCEEDINGS

53. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Faculty of
Mechanical Engineering

PROSPECTS IN MECHANICAL ENGINEERING

8 - 12 September 2008

www.tu-ilmenau.de

TECHNISCHE UNIVERSITÄT
ILMENAU

Published by
Impressum

Publisher Herausgeber	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c. Peter Scharff
Editor Redaktion	Referat Marketing und Studentische Angelegenheiten Andrea Schneider
	Fakultät für Maschinenbau Univ.-Prof. Dr.-Ing. habil. Peter Kurz, Univ.-Prof. Dr.-Ing. habil. Rainer Grünwald, Univ.-Prof. Dr.-Ing. habil. Prof. h. c. Dr. h. c. mult. Gerd Jäger, Dr.-Ing Beate Schlütter, Dipl.-Ing. Silke Stauche
Editorial Deadline Redaktionsschluss	17. August 2008
Publishing House Verlag	Verlag ISLE, Betriebsstätte des ISLE e.V. Werner-von-Siemens-Str. 16, 98693 Ilmenau

CD-ROM-Version:

Implementation Realisierung	Technische Universität Ilmenau Christian Weigel, Helge Drumm
Production Herstellung	CDA Datenträger Albrechts GmbH, 98529 Suhl/Albrechts

ISBN: 978-3-938843-40-6 (CD-ROM-Version)

Online-Version:

Implementation Realisierung	Universitätsbibliothek Ilmenau ilmedia Postfach 10 05 65 98684 Ilmenau

Home / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=17534

53rd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
08 – 12 September 2008

J. Zentner

Comparative Analysis of Domain-Spanning Simulation Concepts Referring to Integrated Drive Systems

In many fields of engineering (e.g. automotive engineering, robotics, automation engineering, biomedical engineering, consumer electronics at al.) the number of optimal adjusted drive solutions, which are more efficient than standard drives increases. This trend is accompanied by two tendencies: On the one hand the drive subsystems (box, energy converter, gear, power electronics, measuring system, different sensors, controller) are combined to form a heterogenic unit. On the other hand, the drives are more and more integrated into the superordinated systems. The analysis of successful examples of integrated drives shows that the most important aspect of the integration process is the sharing of available resources in the drive substructures and the superordinated system. From this point of view in general four orthogonal kinds of integration can be specified:

- **geometric integration** (e.g. compact construction, higher packing density),
- **matter integration** (e.g. the drive box accomplish the function of electromagnetic shielding),
- **energetic integration** (e.g. intelligent energy management),
- **information integration** (e.g. coordinated control of several drive systems by using the state information of the drives).

The four specified integration kinds can occur separately or concurrently. The objective of the integration process is always the optimal realising of drive systems with requirements regarding functionality, economic viability and reliability under defined economical restrictions and deadlines. Successful integrated drive systems distinguish through using the minimum of material resources during fabrication and minimum of energy resources in the operation.

The high integration level also means a high level of interactions between different drive substructures, as soon as between drives and superordinated systems. Thus the domain-spanning modelling and simulation of the whole drive system taking into account

both the phenomena in the several domains and the interactions between the domains is very useful during the development process. In the area of mechatronic drive systems primarily the domains electro-magnetics, mechanics, thermodynamics and control are of interest. Further interesting domains are acoustics, fluid dynamics and other.

In addition to usual natural requirements regarding low computing resources and adequateness of simulation results on the part of industrial enterprises following requirements to domain-spanning simulation are defined:

- Commercial availability of simulators,
- Acceptable learning curve,
- Intuitive and easy operation,
- Assistance features for modelling, parameter identification, and choice of numerical methods.

The existing approaches for domain-spanning simulation of integrated drive systems can be divided into two groups:

- Coupled simulation,
- Joint simulation.

The coupled simulation approach bases on the partitioning of the domain-spanning problem in several domain-specific problems, which are simulated by corresponding specific simulators. The interactions between the substructures are taken into account by data exchange between the simulators and are strongly depended on the coupling algorithm of simulators. The advantages of this approach are the high availability of maturated domain specific simulators for many special problems and the opportunity of modelling with relatively high level of detail. The main disadvantage is that the interactions, which are often most interesting, are depended by the organising of data exchange between the simulators (coupling algorithm, sequencing of simulations, fixed or variable communication step, size of communication step, uncertainty of variables to be transferred and other).

In the joint simulation approach the domain-spanning problem are simultaneously simulated by means of one simulator. This approach can be divided into two groups again: Joint simulation by means of established

- Mono-disciplinary or
- Multi-disciplinary simulator.

There are two ways for applying of mono-disciplinary simulators. The first way consist in the modelling of domain own effects as usually and the mapping of the influences of not

belonging domains by means of concepts of the dominant domain. This way is especially feasible in cases of weak interactions, when only the influences of other domains on the dominant domain are interesting, but not the phenomena in other domains. The second way consist in the modelling of the whole system by means of concepts of the dominant domain applying the physical analogy relations. This way is restricted by limitations of physical analogy relations and loss of plausibility. A general difficulty in the domain-spanning simulation with a mono-disciplinary simulator is that the solver is adjusted only for domain specific problems. However, both ways are very friendly for users, which are specialists in the dominant domain.

By applying of an a priory multi-disciplinary simulator both the domain-specific phenomena and interactions are modelled by a general formalism (e.g. general network theory, bond graph theory and other), which is more or less universally. This approach also bases on the physical analogy relations with their specific restrictions. The advantages are that the solvers are adjustable for multi scale problems. Thus the simulation results are as rule better than in the case of mono-disciplinary simulators. In the table below the results of comparative analysis of two approaches is represented. The chosen comparison criteria are relevant for industrial enterprises.

Table 1 Comparison of coupled and joint simulation approaches

Criteria	Coupled Simulation	Joint Simulation
Cost	-	+
Availability	0	+
Learning curve	-	+
Operation	-	+
Assistance	-	-
Suitability for analysis	+	0
Suitability for synthesis	-	0
Transparency of models	+	-
Level of detail of domain specific phenomenon modeling	+	0
Level of detail of interactions modeling	-	0

In order to combine the advantages of both approaches a mixed simulation approach are proposed (see fig. 1). This approach represents a concept of cooperation of the domain-spanning model with the domain-specific models with different levels of detail. The proposed approach meets especially the demands of

- equal consideration of the domains mechanical engineering, electrical engineering, thermodynamics as well as their interactions;
- including the control aspects;

- vertical compatibility between the models of the same domain with different levels of detail;
- horizontal compatibility between the models with the same level of detail, which belong to different domains;
- suitability for analysis as well as for synthesis;
- supporting of the top-down design approach.

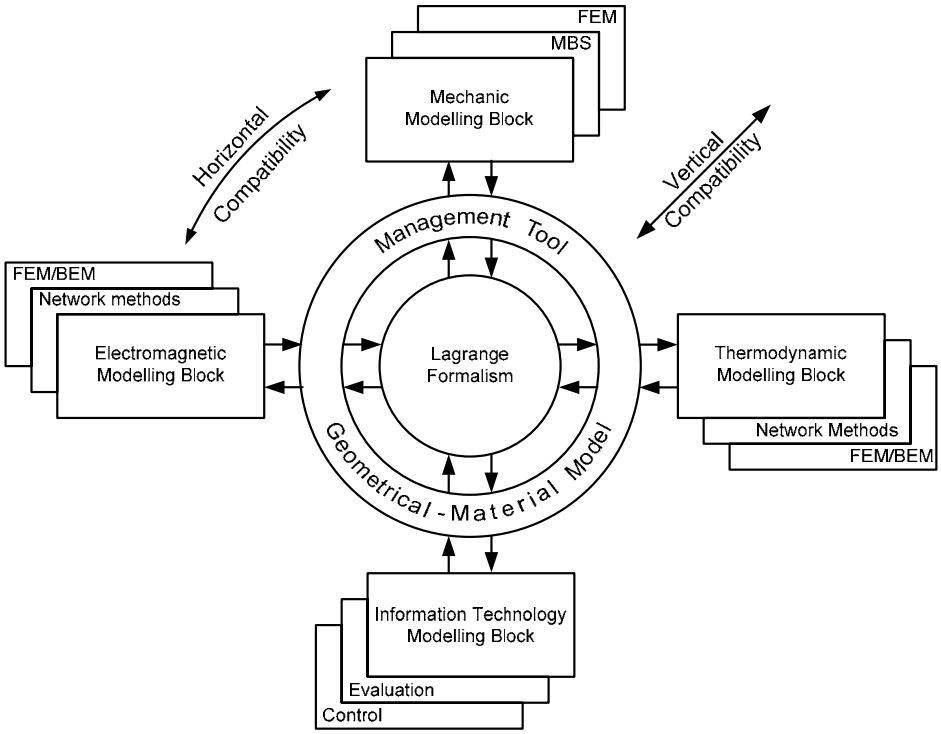

Fig. 1 Structure of the mixed simulation approach for integraded drive systems.

For more detailed description of the mixed simulation approach and its applying for the simulation of integrated drive systems see [1], [2].

References:

[1] Zentner, J.; Volkert, R.; Kireev, V.: Domänenübergreifende Modellbildung mechatronischer Antriebssysteme. Mechatronik 2007, Innovative Produktentwicklung, Tagung Wiesloch. VDI-Berichte Nr. 1971. Düsseldorf: VDI-Verlag, 835-847.

[2] Zentner, J.; Volkert, R.; Kireev, V.; Schneider, M.: Domain-Spanning Modelling of a Magnetic Levitated Multi Coordinate Drive. 10th International Conference on New Actuators: Ac-tuator 2006, Conference Proceedings, pp. 820-823, Published by HVG Hanseatische Veranstaltungs – GmbH, Bremen, 2006.

Author:

Prof. Dr. Johannes Zentner
Technische Universität Braunschweig,
Institute of Electrical Machines, Traction and Drives
Hans-Sommer-Straße 66
D-38106 Braunschweig
Phone: +49 531 391 3901
Fax: +49 531 391 5767

E-mail: j.zentner@tu-braunschweig.de