TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUT FÜR BAUINFORMATIK

PROF. RAIMAR J. SCHERER

JAHRESAUSBLICK

RESEARCH AND LECTURE ACTIVITIES IN 2011

December 2010

Research at the ”Institute of Construction Informatics – Bauinformatik” (CiB) is in two directions:

Applied Informatics and ***Applied Uncertainty and Fuzzy Methods***

The view of the brochure is directed to the future, i.e. to new ideas and what is planned in 2011, based on the results achieved in 2010. Current research topics are: (1) building information models, (2) intelligent engineering structures and construction methods, (3) virtual organizations, (4) project risk and simulation management, (5) dynamic process modelling, (6) structural uncertainty, (7) earthquake engineering and (8) e-learning. Major methods applied are object-oriented modelling and management, engineering and business ontologies, description logic, service-oriented architectures, grid computing, fuzzy logic, stochastics and information mining.

2010 was a very busy year for the institute. Besides the national ICT leading project MEFISTO that started successfully in 2009 and the EU project Trans-IND and the national projects GeoTechControl, the national EFRE/SAB project EGSA and the EU projects HESMOS and SARA started in 2010, whereas another national project, eWorkBau, will start in March 2011. This bundle of projects covers a wide area of civil engineering application, spreading from structural engineering over energy-efficient building, wind and earthquake engineering and geotechnical management to construction management, sensoring, simulation and control and will allow us the development of informatics and numerical methods despite different application needs.

The institute strongly promotes ICT in research and industry. Prof. Scherer is chairman of the European Association of Product and Process Modelling, that held its 8th ECPPM conference at the University College Cork, Ireland from 14th to 16th September 2010. The conference again brought together leading European academic and industrial researchers and developers in construction ICT, eeB and BIM working groups (*http://www.ecppm.org*). The next conference will be held in Rejkyavik, Iceland in June 2012.

Know-how transfer to the industry has a high priority for the institute to facilitate practical exploitation of developed innovative ICT solutions. For the industry CiB is a National Information Point in construction ICT. CiB is active in international and national standardization bodies in the domains of ICT-related product, process, and document modelling and holds chair and vice-chairman positions there.

In October, the institute co-organized the Mefisto conference at the Dresden International Congress Centre (see *http://mefisto-bau.de/congress/*) and the conference “Bauinformatik – Baupraxis” (construction informatics – construction practice) (see *http://springhin.de/workshop)*, both supported by the “Dresdner Bauinformatik-Gesprächskreis” (Dresden Construction Informatics Roundtable).

E-learning activities have been continued and the related construction simulation program further developed. With the newly acquired project eWork Bau a valuable acceleration in e-learning is expected in the next years. The European on-line master course “IT in Construction”, co-ordinated by the University of Maribor, Slovenia, is now in its 7th academic year and students can be enrolled in 7 European universities. Lectures on applications of ICT to improve energy efficiency of buildings have been developing in the REEB project. See *http://www.ict-reeb.eu/*

Collaborative research continued based on the new research projects. In 2010, Prof. Thomas Froese from the Canadian University of British Columbia in Vancouver visited the institute for about three weeks and has successfully contributed to the Mefisto project. Collaboration contracts have been approved with the University of Applied Sciences of Northwest Switzerland (Prof. Breit and Prof. Häupi), the University of British Columbia Vancouver, Canada (Prof. Froese) and the Stanford University, USA (Prof. Fischer).

Many personal changes happened in 2010. Michael Baling and Romina Kühn have left the institute for other destinations. On the other hand new researchers have joined our team: Dipl.-Medieninf. Andreas Hollmann, Dipl.-Ing. Arch. Helga Tauscher, Dipl.-Ing. Arch. Romy Guruz, Dipl.-Ing. Dipl.-Inf. Mathias Kadolsky, Dipl.-Medieninf. Ken Baumgärtel, Dipl.-Ing. Kathrin Binye and in the ICT-Lab MSc Zeeshan Mehmood. The institute staff now covers a broad range of expert domains and is multi-lingual, with researchers from Bulgaria, Iran, Peru, Russia, Syria and Turkey.

Some further information can be found at our web pages *http://tu-dresden.de/biw/cib*

Dresden, in December 2010 Raimar J. Scherer

Institute of Construction Informatics

		Phone extension	Email name
Head of Institute	Prof. Dr.-Ing. Raimar. J. Scherer	3 35 27	Raimar.J.Scherer
Leading engineer	Dr.-Ing. Peter Katranuschkov	3 22 51	Peter.Katranuschkov
Head IT Lab	Dr.-Ing. Uwe Reuter	3 57 28	Uwe.Reuter
Secretary	Ilona Jantzen	3 29 66	Ilona.Jantzen

Teaching staff

Dipl.-Ing. Gerald Faschingbauer	3 42 62	Gerald.Faschingbauer
Dipl.-Ing. Wael Sharmak	3 46 15	Wael.Sharmak
Dipl.-Ing. Ronny Windisch	3 97 75	Ronny.Windisch
Dipl.-Medieninf. Alexander Wülfing	3 57 43	Alexander.Wuelfing

Researchers

Dipl.-Medieninf. Ken Baumgärtel	4 25 42	Ken.Baumgaertel
MSc Alexander Benevolenskiy	3 57 42	Alexander.Benevolenskiy
Dipl.-Ing. Kathrin Binye	4 25 40	Kathrin.Binye
Dipl.-Ing. Sebastian Fuchs	3 38 23	Sebastian.Fuchs
Dipl.-Ing. Arch. Romy Guruz	4 25 44	Romy.Guruz
Dipl.-Medieninf. Frank Hilbert	3 57 43	Frank.Hilbert
Dipl.-Medieninf. Andreas Hollmann	4 25 39	Andreas.Hollmann
Dipl.-Ing. Ali Ismail	3 45 30	Ali.Ismail
Dipl.-Ing. Dipl.-Inf. Mathias Kadolsky	4 25 43	Mathias.Kadolsky
MSc Faikcan Koğ,	3 57 45	Faikcan.Kog
MSc Zeeshan Mehmood (IT lab)	3 98 17	Zeeshan.Mehmood
MSc Ksenia Rybenko	3 57 42	Ksenia.Rybenko
MSc Sven-Eric Schapke	3 36 71	Sven.Schapke
Dipl.-Ing. Ulrike Schirwitz	3 46 41	Ulrike.Schirwitz
MSc Yaseen Srewil	3 97 76	Yaseen.Srewil
MSc Tatiana Suarez	3 57 45	Tatiana.Suarez
Dipl.-Ing. Arch. Helga Tauscher	4 25 41	Helga.Tauscher
Dipl.-Ing. Ulf Wagner	3 57 41	Ulf.Wagner
MSc Amin Zahédi Khaméneh	3 49 57	Amin.Zahedi

PhD students extern

Dipl.-Ing. Alexander Gehre	Alexander.Gehre@semproc.de
MSc Nazereh Nejatbakhsh	Nazereh.Nejat@opb.de
MSc Hermin Kantardshieffa	kantards@informatik.htw-dresden.de

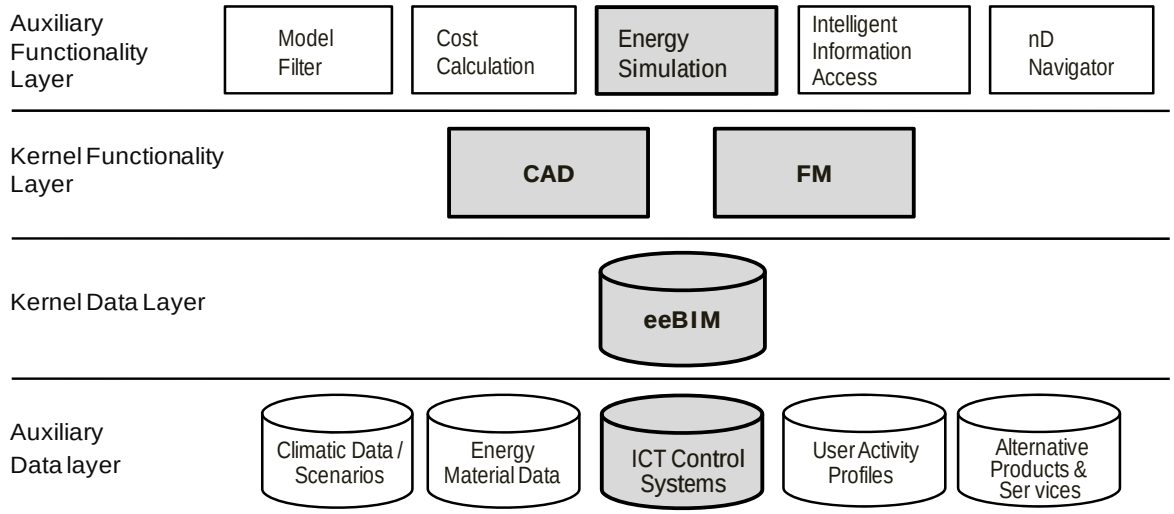
Phone:	+49 (351) 4 63-{Phone extension}
Fax:	+49 (351) 4 63-3 39 75
Email:	{FirstName.FamilyName}@tu-dresden.de
WWW:	http://tu-dresden.de/die_tu_dresden/fakultaeten/fakultaet_bauingenieurwesen/cib
Regular Mail:	Technische Universität Dresden, Institut für Bauinformatik, 01062 Dresden
Packages:	Technische Universität Dresden, Helmholtzstraße 10, 01069 Dresden
Visitors:	Technische Universität Dresden, Nürnberger Str. 31a, 01187 Dresden

Development of an Integrated Virtual Energy Laboratory for Life-Cycle Evaluation of the Energy Performance of Buildings

Peter Katranuschkov

Objectives

The energy performance of a building depends on multiple factors ranging from the climatic conditions and the building materials used to the capabilities of the installed building automation systems and the actual activities of the occupants. In order to determine and control energy performance properly, a number of different information sources have to be taken into account and a number of different methods have to be applied starting already in early design, where the basic materials, spaces and systems are decided, and continuing throughout the operational phase, where decisions about redesign, refurbishment and repair have to be weighed up comparing improved energy performance vs. costs. Due to that complexity, it is often very difficult to take informed and optimized design and management decisions. The objective of this research is the development of an Integrated Virtual Energy Laboratory (IVEL) that can close the existing essential gaps between intelligent building data provided by building automation systems and the data from building design and construction so that complex energy performance and cost simulations can be done transparently, economically and in all life-cycle phases.



Principal software architecture

Approach

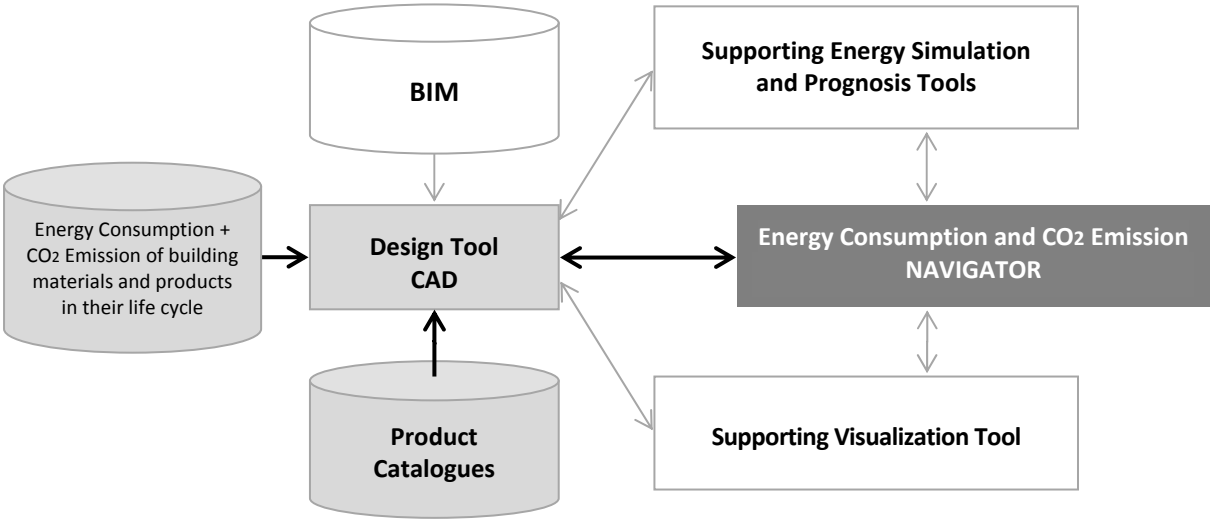
A central issue for the realization of the envisaged Integrated Virtual Energy Lab is the achievement of information interoperability, which will be done by appropriately enhancing the standard Building Information Model (BIM) of the BuildingSMART initiative, IFC (ISO PAS 16739) towards a true eeBIM. The overall approach is to build the IVEL as an open SOA platform based on eeBIM, BIM-CAD and FM-CAD, extended by development of missing functionalities and services for intelligent access to ICT control systems on the one side and advanced energy analysis and simulation tools on the other side, thereby providing for a coherent and easy-to-use environment for the end users. The main development steps comprise: (1) Specification of the eeBIM and inter-linking it with other needed data into a coherent multi-model framework, (2) Complementing the eeBIM-based multi-model framework with an ontology that would allow to manage complex platform interactions, (3) Extending existing BIM-CAD, BIM-FM and energy simulation tools so that they can seamlessly exchange the required data in both directions, and (4) Integrating FM, simulation tools, sensor networks and other ICT subsystems to achieve continuous monitoring of performance and control of gaps and under-performances. This research work is part of the HESMOS project.

A Design Service for Energy Efficiency Calculation Capturing the Full Material Life Cycle

Romy Guruz

Objectives

The European Commission has established a new Energy Performance of Buildings Directive: Beginning in 2019 new public buildings shall be zero energy consumption and Europe will be looking forward to achieve *Energy Plus Houses*. These buildings should feed solar power back into the main network in the form of electricity. The biggest opportunity to influence the relationship between the energy goals and the architectural design of such buildings is during the early planning phases of a project. Taking that into account, our objective is the development of a design tool for architects that helps to assess *the energy balance* and *the decisions of selecting the materials* in the early planning phases. It should (1) give users an easy and reliable prognosis about the life-cycle energy balance based on well-grounded assumptions, (2) make it possible to demonstrate the potentials for hidden energy reserves in the decisions about building materials, and (3) extend the freedom of planning on the basis of transparently suggested compensation potentials. Thus, it will allow better recognizing different energy situations in the pre-planning phase, instead of taking intuitive or conventional and often inadequate measures.



Principal architecture of the suggested system enabling designers to achieve minimal energy consumption and CO_2 emission

Approach

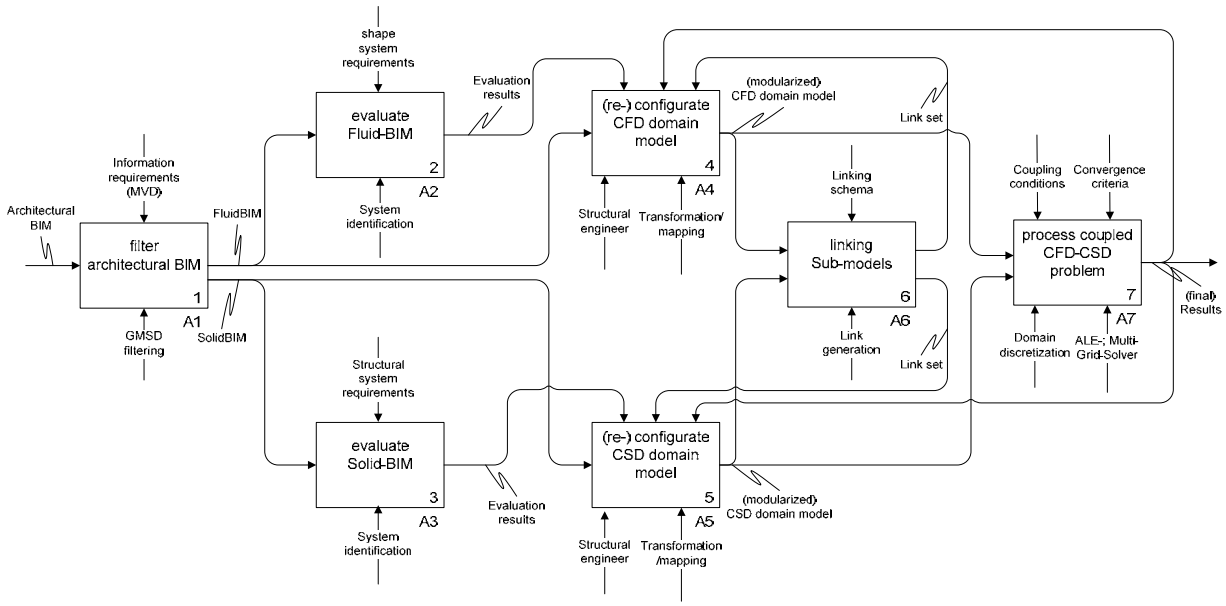
Every material and every applied technology amounts to different energy consumptions and carbon dioxide emissions during its life cycle. It is essential that architects have a CAD-based tool that allows them to know this from the beginning in order to take informed design decision. To retrieve the necessary data, a distinction will be made between fixed and variable data. The fixed data that describe product components can be extracted from manufacturers' catalogues. Such catalogues will be integrated with the underlying Building Information Model (BIM) and applied as examples. The variable data will be derived from the geometry in the BIM. Suitable algorithms to retrieve relevant geometry, material and product catalogue data will be developed for that purpose or existing energy calculation tools will be linked via a BIM-based interface using an overall SOA approach. An additional module will be responsible for the appropriate visualization of prognosis / exploitation data based on the "navigator" metaphor. The envisaged tool will be integrated via Plug-In technology into existing CAD software (e.g. Nemetschek's Allplan). This research work is part of HESMOS project.

BIM-Based Semi-Automatic Sub- and Domain-Model Generation for Coupled Structural-Aerodynamic Analysis

Ronny Windisch

Objectives

In order to design slender and flexible modern tall buildings, efficient structural systems of high-strength materials are used to reduce their weight. These structures exhibit lower damping values than conventional ones, which make them more susceptible to wind-induced excitations resulting in reduced structural safety or possibly causing discomfort to the occupants. Therefore, the wind-induced excitation has to be regarded as an important structural design criterion that requires the knowledge of the accurate dynamic response of the building to any wind load as well as the facilitation of efficient and reliable exploration of various control techniques to achieve suppression of wind-induced excitations and improvement of the building performance. In order to provide the necessary high quality building information and to enhance efficient generation and management of large sets of design variants the coupled structural-aerodynamic computation has to be seamless integrated into the surrounding design environment of the overall building design process. To achieve appropriate information integration for this special purpose a reconsideration of the general BIM-oriented integration approach consisting of a) BIM architectural modelling (CAD), b) BIM-data management, c) BIM-data transformation/mapping, d) domain-specifically structured BIM and e) BIM-data modification using specialized domain applications, is needed.



Conceptual information and process workflow of semi-automatic BIM based sub- and domain-model generation

Approach

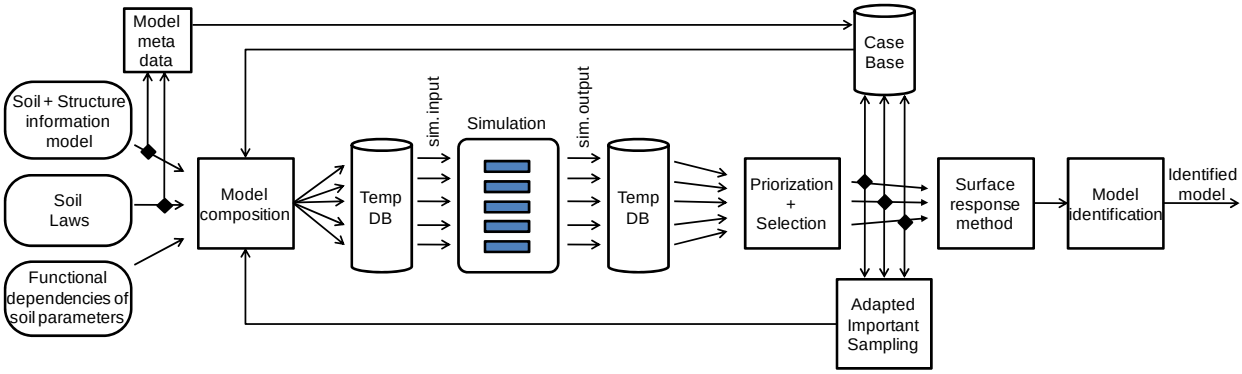
The proposed approach addresses an efficient iterative design and validation process regarding the aerodynamic building requirements that incorporates semi-automatic domain model generation with their specific model elements and structure and modification as well as version management and evaluation. Starting from the architectural BIM the required fluid- and solid-sub-model has to be extracted. This is done by using the GMSD approach based on predefined model view definitions. Due to the various mapping capabilities of the different CAD applications and the needed model simplifications and assumptions the resulting sub-models have to be evaluated in order to identify missing or incorrect information that violates the definitions of the domain systems, namely the building envelope and the structural framework. The evaluation results are used to control the configuration of the CFD (computational fluid dynamics) and CSD (computational structural dynamics) domain models. The pre-processing of the CFD and the CSD domain (domain discretization, formulation of the boundary layer and the boundary conditions) and the calculation of the coupled CFD-CSD-problem is based on the configured domain models. Since the calculation may cause significantly model changes leading to different model versions a linkage between the domain-models is established in order to ensure consistency regarding to both the CFD and the CSD domain model. This research work is part of the SARA project.

Integrating Knowledge-Based Methods and Distributed Computing Power to Facilitate Simulation-Based System Identification

Gerald Faschingbauer

Objectives

The objective of this work is to use measurement data of geotechnical construction projects, recorded simultaneously to construction, for continuous system identification. Therewith mechanical models will be identified, that represent the observed physical effects as close as possible to reality. Continuous model updating is the pre-requisite for the construction-simultaneous increase of knowledge about the soil, the geotechnical structure and the surrounding area. This is required for the qualified and well-founded control of the construction method and proactive prevention of failures. Because of the non-linearity of complex soil models closed analytical system identification is not possible. Therefore a simulation-based system identification method is proposed. Simulation-based system identification means, that model candidates will be sampled by deterministic variation of soil law and soil parameters and the system behaviour will be simulated with each model candidate. To span the full information space results in sampling of m parameter variations for p parameters and hence using cross-join combination in m^p model candidates -variation of soil law, investigation of different construction phases, etc. not yet included. Simulation of that high number of model candidates with non-linear material behaviour is only possible if computation power of distributed cloud or grid computing is used. A number of 10^6 parallel computations may be realistic in today's grids. With intelligent restriction of the high number of model candidates to a subset of the cross-join, qualified simulation-based identifications can be already done with today's feasibilities of parallelization.



Knowledge- and simulation-based system identification

Approach

The restriction of the number of model candidates will be done with a combination of methods: (1) interdependencies of model parameters will be considered, i.e. parameter values will not be combined if their combination is physically not meaningful; therefore the interdependencies of soil parameters will investigated, the functional relationships will be formalized with mathematical functions and integrated in an already existing description-logic-based model composition methodology. (2) Further enhancement of efficiency is possible if the model composition methodology will be extended by a case-based reasoning system. Model candidates that delivered well-fitting and plausible simulation results will be automatically stored in a case base, together with attributes describing the investigated engineering situation, i.e. soil and structure, as well as a grade of the achieved simulation quality. To realize this approach a classification schema of physical effects should be developed, which can describe specific physical situations. The use of the fact base requires research on domain-specific similarity measures for various geotechnical problems in order to enable reasoning from an actual situation of construction to similar, already simulated and investigated cases of former projects. Once identified a similar case from former projects, the model candidates will be sampled especially in the range of former successful realizations. (3) The importance-sampling method and the response-surface-method should be adapted and integrated in the sampling process, so that step-by-step refinement of parameter candidates with weighting of especially promising value ranges can be achieved. This research work is part of the GeoTechControl project.

Solving Complex Civil Engineering Computations with Grid and Cloud Computing

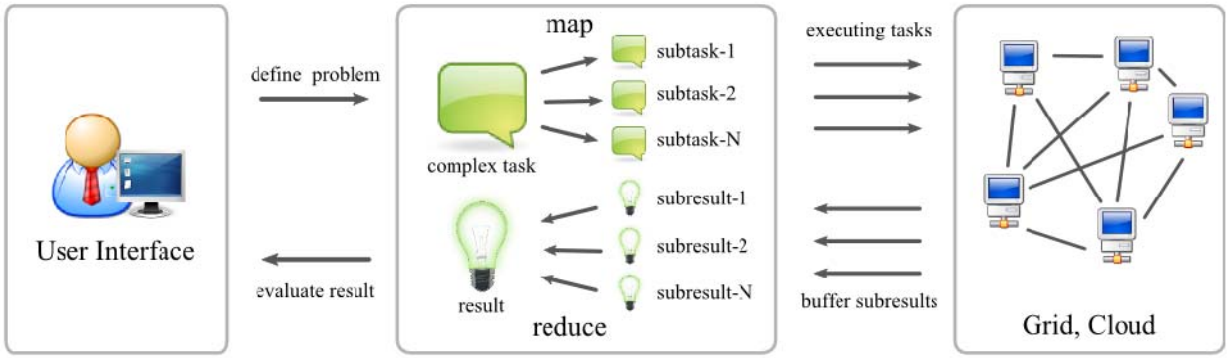
Andreas Hollmann

Objectives

Engineering decisions during the construction process require continuous monitoring as well as interpretation of sensor data and system behavior based on physically justifiable mechanical models. Nevertheless, solving time for finite element analysis of mechanical models for only one model candidate on a normal computer is about twenty minutes for 2D-problems up to several hours for 3D problems. Especially in geotechnical engineering, model uncertainties are rather high, because of heterogeneity of soil and the difficult determination of soil parameters. Therefore parameter studies are required.

For parameter studies large number of automatically generated model candidates must be processed. After solving all model candidates, the model which is more suitable for the calculation of the current construction situation can be chosen.

Today it is not possible to solve such large number of model candidates on a normal computer, because of missing computing power. Recently there was some progress in technologies, which allow to parallelize computationally intensive tasks in a network on many computers and hence a large number of cases can be solved in parallel on many computers in a short time. Technologies like grid or cloud computing have been established and are meanwhile used also from the industry. The missing computing power can be bought on demand from cloud computing providers like Amazon, IBM or Microsoft.



Parallelization of N-tasks in a grid or cloud

Approach

Current existing grid and cloud technologies must be evaluated with respect to execution time, reliability, availability, scalability, development and deployment cost. The methods for the development of complex practice relevant systems have to be based on established system engineering development methods. First of all the following questions must be answered: (1) how to adopt and paralyze existing solver-software in a grid or cloud? (2) how to generalize developed methods and software to make it reusable for other civil engineering problems?

The envisaged system will be a framework for building an application to solve complex parallel computations in a grid or cloud. The system will consist of three parts: (1) user interface layer – gives the control of the whole system to a civil engineer (2) MapReduce layer – maps the complex task to many smaller tasks and produces final result by merging produced subresults together (3) Grid, Cloud layer – computing grid or cloud infrastructure, which provides computing power and is used to solve computational intensive tasks.

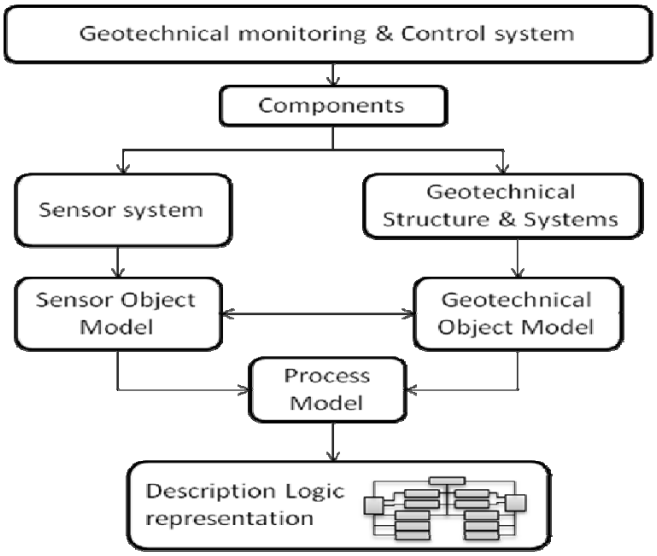
The knowledge of this research can be reused in related projects, thus the software will be developed as a framework with well documented extension and variation API hook points. Also it should be built on established technologies, which will be supported in the future. The envisage framework will be independent of any used grid or cloud computing technology, thus in the future the more cheaper grid or cloud provider can be chosen to reduce project costs. This research work is part of the GeoTechControl project.

Description Logic Supported Representation of Geotechnical Structures Coupled to the Construction Process

Tatiana Suarez

Objectives

The observational method in geotechnical engineering requires continuous recording of measurement data, model updating to the observed effects and subsequent engineering interpretation of the situation as well as possibly the adaption of the construction method, if required by the detected facts. The main objective of this work is to improve data acquisition and data management during construction-simultaneous monitoring and model-updating of geotechnical engineering projects. Taking into account that both the structural system and the sensor system are somehow connected to each other and both are changing continuously during the construction process it is evident that information needed for monitoring and model-updating are highly cross-linked and transitive relationships have to be considered to query comparable sets of sensor and prognosis data. Therefore an object oriented model of the geotechnical structure, the soil as well as the monitoring system integrated with a process model of the construction process will be developed to be the information core facilitating the assignment of both prognosis data and sensor data to structural elements and soil elements and to the construction states.



Structure diagram of the object-oriented description logic supported system

Approach

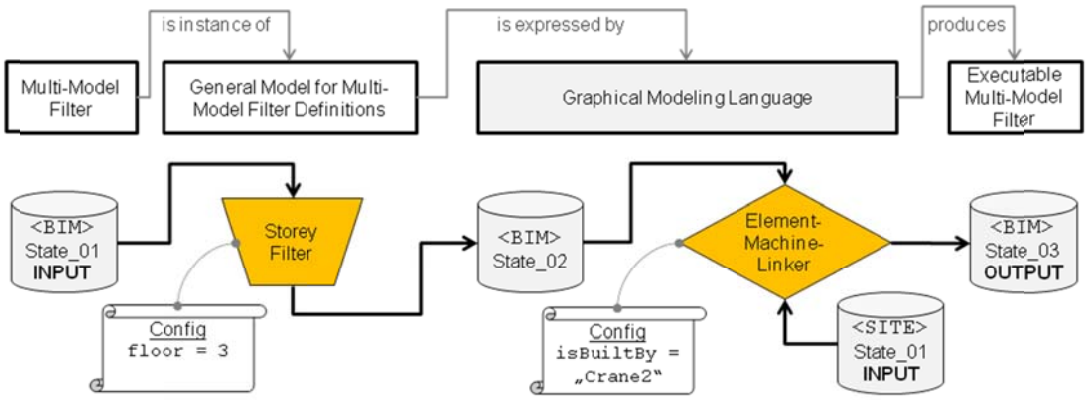
Initially, domain specific classes of structural elements in geotechnical engineering, soil elements as well as sensors will be developed as an entity-relationship model. In order to use already existing classes, e.g. for geometrical representation, topological relations or material definitions the schema to be developed will be based on the Industry Foundation Classes (IFC). Based on an integrated, description-logic-based product and process meta model, which integrates 3D object oriented modeling with discrete process models to 4D models, product-process-modules will be designed for typical structures and construction methods. The realisation of the product and process model with description logics offers the explication of knowledge, implicitly contained in the model. The main advantage of the product and process model based on description logic and ontologies is that both the models and the deduction calculus can be flexibly extended. Hence the product-process-modules will be supplemented by deduction rules that allow the inference-based instantiation of complex 4D-models of geotechnical engineering projects on any level of detail. The final objective is to use these decision-logic-based 4D-models to model the evolving structure and the sensor system in 4D and to use the transitive relationships between objects and process elements to decide about assignment of data. This research work is part of the GeoTechControl project.

A Model for Filter Definitions in Multi-Models

Sebastian Fuchs

Objectives

Multi-models are a promising approach to achieve interoperability in construction information processes. Its main challenge is the use of unmodified existing data schemas to support instant adoption. To keep the independent character of the assembled primary model instances, multi-models must explicitly express the inter-model information relations using special *Link Models*. In this way it will be possible for any software to retrieve multifaceted information, which otherwise would be inaccessible automatically. However, that approach introduces new problems on filtering due to the schematic independence of the involved "elementary" models. While traditional single model filters can rely and operate only on the schema of their domain model, nontrivial multi-model filters must query and combine over the various orthogonal aspects described by the set of elementary models. Therefore they must operate on the specific schema of every elementary model as well as on the link model of each model pair. Furthermore there are several filter task relevant approaches with their corresponding implementations that have to be taken into account, e.g. defining a sub schema or filtering by manual selection. These conditions lead to complex filter configurations to be performed by the end user of multi-model software. The objective of this work is to structure and improve the definition process of multi-model filters. An object-oriented model for filter composition and model linking will enable formal multi-model filter definitions and the execution of them. As a step towards a *multi-model engineering language*, a graphical modeling language for the filter definition model will be developed. Through its use (1) the user's intention about complex filter definitions can be more easily expressed, (2) a given filter definition can be restored and analyzed, and (3) the user will be enabled to reuse already defined filter components.



Semantic and formal context (top) and potential syntax of the proposed graphical language (bottom)

Approach

The overall approach is to consider a multi-model filter as a collection of elementary filters - each operating on a specific elementary model type only - and a collection of corresponding result set intersections based on link models. In a first step, the formal model of multi-model filter definitions is developed. Its context is the granular structure of multi-models as well as their scope of filtering in software applications. The purpose of the model is (1) to find and express the adequate generalization of filters, (2) to allow orchestration of filters and link models, and (3) to provide complexity reducing structural features. The first of these three issues will be tackled by representing the common structure and attributes of filters and link models by a class structure with the operated data type as generalization (e.g. templates in UML, generics in Java). The second issue will be tackled by defining associations in a way that type-safe chaining of filters and link-models is possible. To provide adequate structuring of filter definitions as aimed by the third issue, a filter may consist of other chained filters, which will be represented by a composite structure for the filter classes.

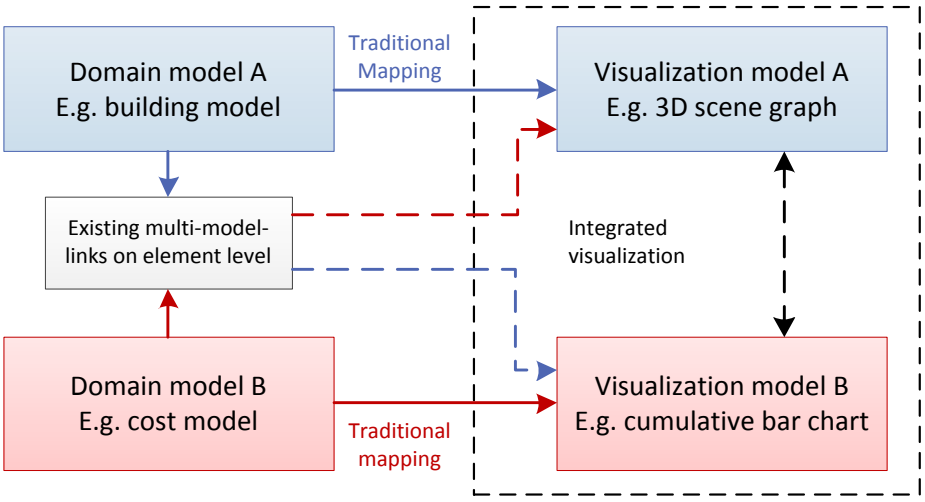
Given an appropriate implementation of each elementary filter as well as a mechanism to provide the configuration for it, runtime execution of instances of the described model will be possible. As proof of concept, a prototype of a graphical modeling language will be implemented to support the definition of model instances by the end user. Its integration into the institute's own Multi-Model Assembly and Analyzing platform (MMAA) will provide a basis for validation of the developed concept. This work is part of the mefisto, the SARA and the HESMOS projects.

A Visualization Language for Communication in Product Model Based Building Planning Processes

Helga Tauscher

Objectives

The increasing usage of building model based methods is accompanied by an increasing amount of abstract data, which lacks the tangibility of traditional plans and specs. Current research aims at the integration of different domain models subsets into interlinked multi-model groups. Thereby amount, density and complexity of information content are increased further. Approaches to narrow down the amount of data according to the needs of common tasks in the planning process, such as the Model View Definition (MVD) approach of the IFC, aim for reduction of this complexity. But they are targeted on interoperability among software tools for the respective tasks. Consequently they treat the interface between different domains primarily as a matter of data exchange thereby disregarding human communication and visualization aspects. Software tools for the development of design solutions on the other hand usually do generate visualizations along with singular domain models. But they neither deal with the increased entropy in multi-models nor do they provide a connection between the models and the visualization which goes beyond temporary generation on-the-fly or permanently decoupled visualization. There is a research deficit regarding the relation between the multi-domain building model and its visual representation.



Mapping different interlinked domain models to visualization models

Approach

From a technical point of view visualization can be described as a mapping or transformation of data subsets to visualization entities which can be rendered onto a 2D surface. If the surface is dynamic, these objects might be enhanced with interaction capabilities. In order to describe specific visualization types the required data subsets, the mappings and transformations as well as the supported interactions have to be specified in a formalized way. To develop a respective meta-model existing visualization ontologies will be extended by means of generalization from paradigmatic cases. Based on the data exchange requirements already identified for certain planning processes, the needs for corresponding visual presentations will be analyzed. Both established visual presentations and rather new screen-based presentations will be taken into account. Exemplary presentations for selected communication scenarios will be examined in terms of the model source data required as well as the transformation of that data into the visual presentation aimed for. Existing methods to query and filter domain models or sub models will be reviewed regarding their limits when employed for visualization tasks. Special attention will be paid to the specific requirements of interlinked multi models as illustrated in the figure above. Appropriate concepts will be figured out for the integration of data from different domain models into visual presentations as well as for the presentation of relations between multiple domain models and of comparison results for similar domain models. This research work is part of the mefisto and eWorkBau projects.

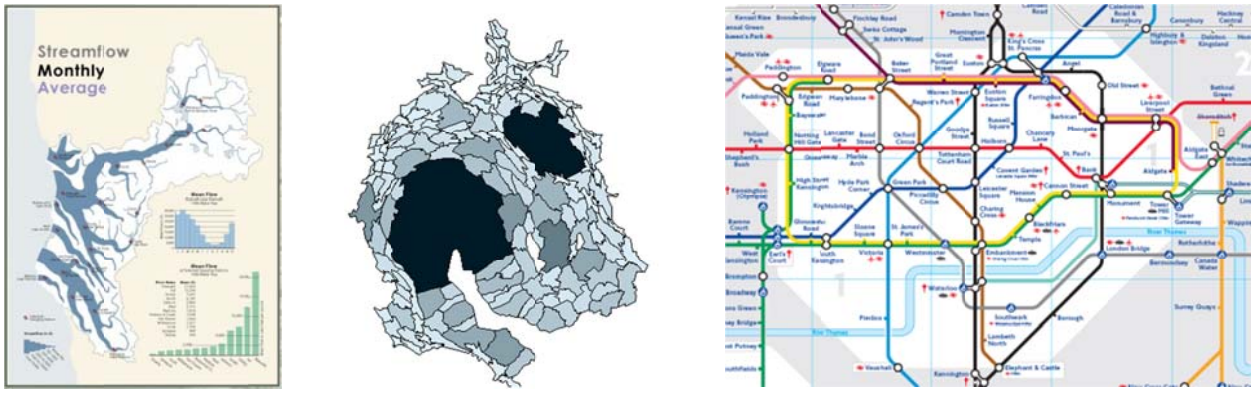
Anamorphic presentations of spatial objects and their non-spatial properties for the visualization of building models

Helga Tauscher

Objectives

Complex issues can be described as multidimensional data spaces. Visual presentations can enhance the understanding and analysis of these issues, because visual perception is better suited for multidimensional data then the perception of textual presentations and well developed for humans in general and for professionals trained in producing and reading drawings and images in particular - as there are architects, graphic designers, civil engineers etc. Two-dimensional (screen or printed) presentations of complex issues are generated by mapping the values of individual data space dimensions onto so called visual variables. Individual presentation types are limited in terms of the visual variables (e.g. position, size, color) they provide. Thus the complexity of the presentable data is limited as well. That's why for multidimensional data spaces the dimensions to be presented together in one presentation have to be chosen carefully.

When dealing with spatial issues, projection of the spatial dimensions of the data onto the spatial dimensions of the visualization model seems natural. This is the method employed for geographic maps, building floor plans and even perspective illustration of real world objects. This way most of the visual variables are bound to the spatial properties of the presented issue, leaving only color, annotations and symbols freely usable for non-spatial properties. Furthermore the spatial proportions of the presented objects dictate the intensity of their presence in the visualization: Big objects in size will be more dominant then small ones even if the small ones are more important or of a higher score in terms of a relevant non-spatial property. On the other hand - when traditional methods of data visualization (bar charts, diagrams etc.) originally developed for non-spatial data are used for spatial objects with non-spatial properties, the spatial properties of the visualized object are usually totally lost in the presentation. This way it is impossible to show relations between spatial and non-spatial properties in the visual presentation.



Examples of anamorphic maps: Rivers streamflow, Areal cartogram by number of inhabitants, tube map

Approach

To overcome the limitations of both described approaches, the spatial properties of the objects could be decoupled from the spatial dimensions of the visualization partially only, leaving topological relations intact, while distorting the proportions of the objects. This approach is utilized by anamorphic maps as e.g. those from the worldmapper project. This project collects area cartograms showing world maps where territories are re-sized according to a subject of interest, e.g. population. Another form of anamorphic maps are so called distance cartograms - showing networks re-shaped in order to reflect characteristics of the relation between to nodes (e.g. relative travel time) as the distance of those nodes.

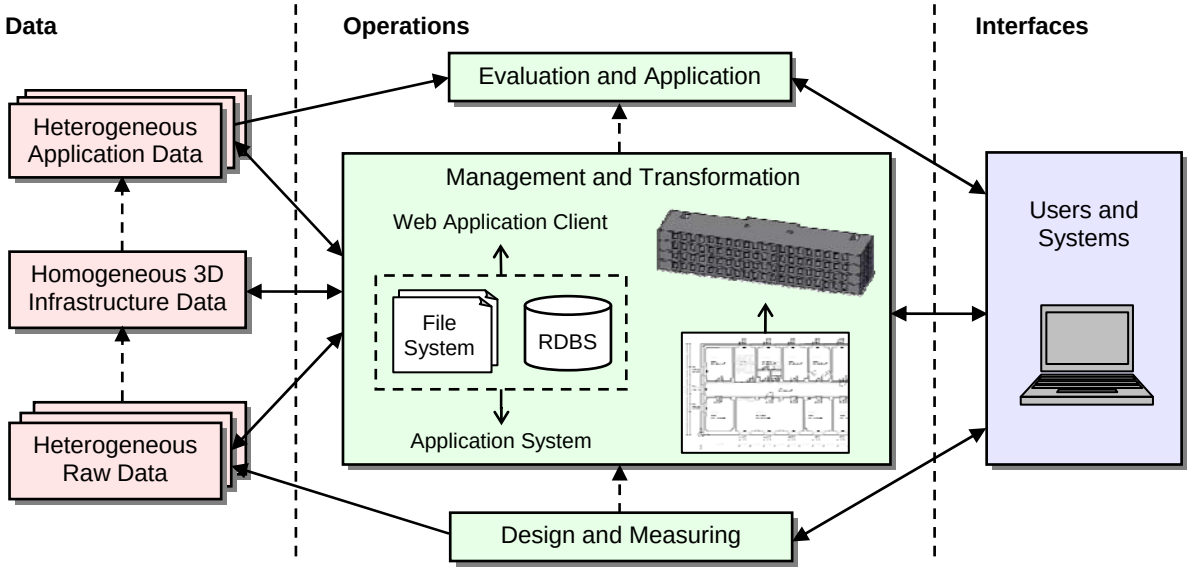
Objective of research is the utilization of anamorphic presentations for tasks during construction planning. To achieve this, existing types of two-dimensional anamorphic presentations will be reviewed in-depth including methods of their generation. Subsequently the possibility of translating the concept for anamorphic presentations of three-dimensional spatial objects will be investigated. In a third step the use of both two- and three-dimensional anamorphic presentations for the domain of architecture, building design and construction planning will be explored.

Managing Data of a Three-Dimensional Campus Infrastructure Model

Hermin Kantardshieffa, Wolfgang Oertel[1]

Objectives

The sustainable development of a 3D campus infrastructure model combines computer graphics, data bases, knowledge processing, and network technology to build an exhaustive representation of the buildings of a university, their exterior environment, their interior equipment, as well as a set of associated processing operations. At the moment, spatial campus data exist in the form of a variety of heterogeneous digital or paper documents. There are raw measurement data, a number of 2D engineering drawings, selected 3D visualization models, several textual table and data base documents, as well as data firmly bound in IT systems. The aim of a current project V3CIM[2] is the development of a viable software system for interactive and automated creation, management, and use of a comprehensive and consistently 3D virtual model of a campus infrastructure. The system will work to a large extent automatically and will allow the generating of a centralized 3D model from heterogeneous raw data and support campus-typical application functions in the fields of information, management, and visualization.



Software architecture of the Campus Infrastructure Information System

Approach

The main approach of the proposed system is the handling and unifying of heterogeneous spatial documents that are organized vertically on three different levels according to a level architecture. The raw data on an internal level represent primary data. The application data on an external level are targeted at specific functions to be offered by the system (facility management, information, visualization, navigation). The bridge between both levels is made by a complete and centralized model organized along the three spatial dimensions on a conceptual level. This 3D model consists of syntactic graphic elements and semantic elements according to a Building Information Model. Horizontally, it can be distinguished between the data, their processing operations, and respective interfaces to users and other systems. All handled data have a graphic nature or at least background. They are managed within a relational data base system combined with a hierarchical graphics document repository. The computational connection between the different graphic data is performed by transformation operations on the basis of standardized interfaces. Therefore, the data are additionally organized in a pipeline-like manner whereby each step stands for a manual or automatic transformation according to a respective interface. In order to be able to perform automated transformations on the modelled and managed 3D campus data, a library of operations is being developed that can be applied at certain points of the graphics data pipeline. The operations are built on knowledge-based representations known from artificial intelligence technologies, such as production rules, constraints, semantic networks, or logic clauses. They are combined in knowledge interpreters with inference mechanisms using several basic match and search algorithms.

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[1] Co-operative PhD thesis with the University of Applied Sciences Dresden, supervised by Prof. Wolfgang Oertel.

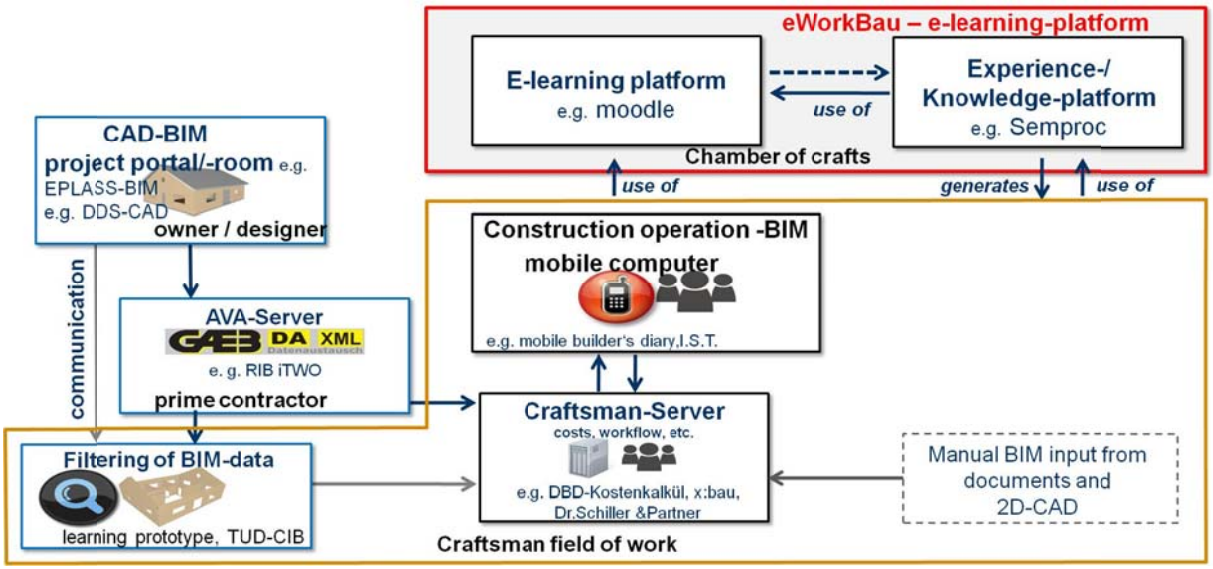
[2] V3CIM (Virtual 3D Campus Infrastructure Model) – http://www.htw-dresden.de/~v3cim – supported by the Saxon State Ministry of Sciences and Arts.

E-learning in the context of mobile model based work

Alexander Wülfing, Kathrin Binye

Objectives

Mobile Model based Work (MMW) using Building Information Models (BIM) and virtual project rooms can help to save time and costs. During the construction process cooperation between different construction participants using different technologies and media from the Information and Communication Technology sector (ICT) is in the MMW unimaginable. Especially the ICT sector is rapidly changing so lifelong learning of the participating qualified employees is a necessary pre-condition if the MMW should be accomplished. With the help of e-learning in the context of WEB 2.0 based learning scenarios it is possible to support these learning processes, e.g. through cooperation, simulations, the possibility of time- and location independent learning and the continuous adaption on the learning behavior. An education concept based on WEB 2.0 technologies will be developed to qualify employees to understand and use the mobile model based work on the base of authentic projects.



Software system architecture for new buildings

Approach

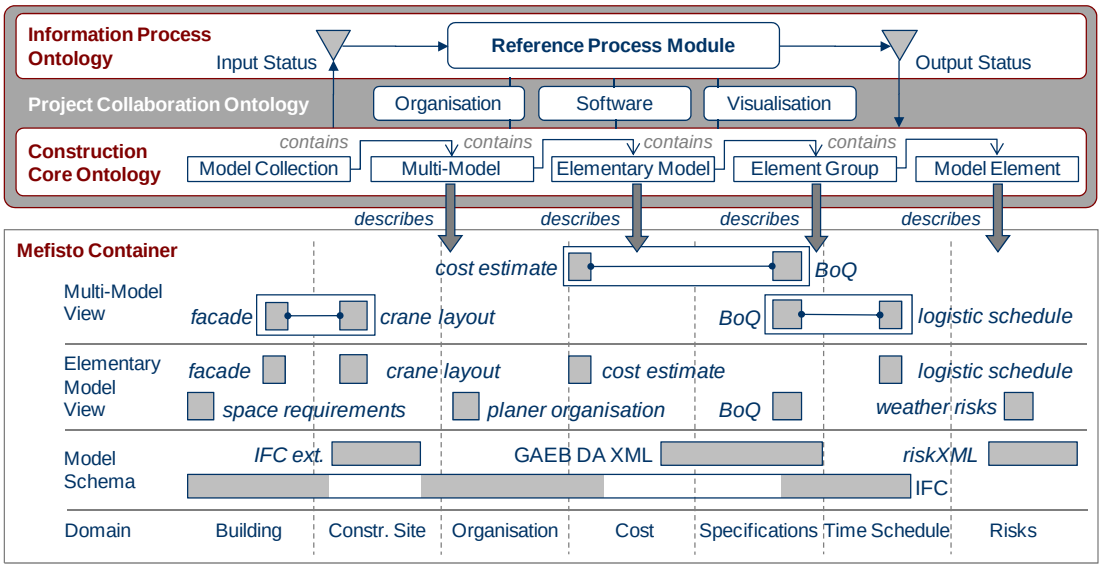
As authentic case projects, a new erected building and a renovate building, both with special focus on energy efficiency, are the base for e-learning education scenarios to understand and use mobile model based work. The development of these scenarios for new construction and reconstruction will be done in cooperation with partners from the industry and the handcraft associations. This is necessary because the MMA differs from the involved business processes and size of the project. One important point in this context is the filtering of all the BIM information because each business process has its own information requirements. This work is the basis to divide the projects in different stages, e.g. what is when to be done (and what not) and which pieces of information are needed and how they are findable/accessible. This knowledge is the base for the description of software requirements for selection of corresponding MMA-/BIM and e-learning content which should be integrated/used by the selected e-learning solution. The above figure shows the proposed MMA software scenario for large projects, where usually the design work is carried out by architects and handed over to craftspeople but the craftspeople are responsible for picking out the right information at the right time. This research work is part of the eWorkBau project.

Hierarchical Reference Modelling of Planning and Controlling Processes using Multi-Models

Sven-Eric Schapke

Objectives

Throughout the last years software applications have entered the market that allow for integrating building models with related construction information to examine, align and further utilise separately developedplanning results. In comparison to central PDM and PLM Systems these applications provide for local coupling of construction planning and controlling models on an as-needed basis. In order to integrate the local tools and their information models a Semantic Service Environment is developed that allows for sharing the resulting multi-models among project participants of different disciplines, functions and management levels. The environment is build upon a common exchange format in form of a multi-model container as well as several dedicated information management services to exchange, transform and analyse visualise the multi-models. Giving the possibility to semantically annotate the multi-models within the container the objective of this research is to coordinate and document the processes for their creation, analysis and reuse.



Ontology-based management of the creation, transformation and use of multi-models

Approach

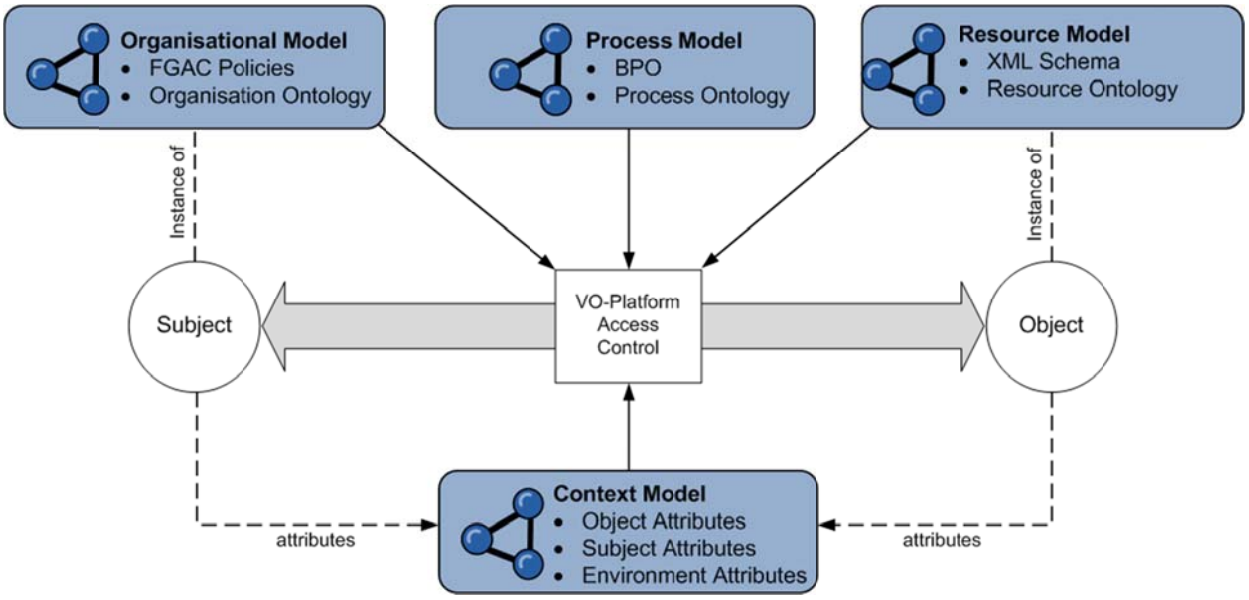
Backbone of the environment is an ontology-based modelling framework comprising a *Construction Core Ontology* (CCO) denoting the content of elementary models and link models within a multi-model and a superordinate *Project Collaboration Ontology* (PCO) describing the processes, organizations and software systems to create and use them. To represent the information processes within the PCO and manage the creation, transformation and use of the multi-models a process management approach is suggested that combines methodologies of business process objects and reference process modelling. Reoccurring planning and controlling processes are described by *Reference Process Modules* (RPM). They define the requirements for the organisational entities, the software systems and the multi-model visualisations in regard to the PCO as well as the informational requirements and process outcome in regard to the CCO. Therefore, the CCO reflects core concepts of planning and controlling models in accordance with standardized as well as non-standardized data schemas, as illustrated above. Moreover, it identifies elementary and multi-model views as they are used in different project phases, application fields and management areas. On an actual project, the process modules can be retrieved, configured and composed using them as building blocks to ad-hoc assemble new process models. The CCO is then used to establish links between a configured process module and related multi-models and deliver it to the software systems of the project participants. A key point for the effective reuse of the process modules and interlinking the models is the coherent structuring of the process models and the related construction planning and management models. Thus, input and output of a process module can be specified by the required/elicited status of certain multi-models, elementary models or model elements. This research work is part of the mefisto project.

Ensuring Minimal Privileges on VO Service Platforms

Frank Hilbert

Objectives

Globalization and corporate mergers have led to increased competition within the construction industry while the customers' requirements are constantly increasing. In order to remain competitive under these market conditions in the future, the opportunities for small and large companies are found in new and innovative forms of organisations, which consolidate the core competencies of their members in a time-limited cooperation for the processing of a common construction project. For virtual organisations, where legally independent companies with sometimes different interests cooperate on Service Platforms, confidentiality and privacy are important acceptance factors. Therefore, not only the maintaining of operational and business secrets, which are often of great economic value for a company, but also the ensuring of adequate data security for the informational assets of the business relationship, are crucial. In order to increase acceptance by collaborating on a common service platform, it is therefore necessary to enforce one of the basic principles of information protection - the principle of least privilege. For this, a situation-specific identification and context-dependent enforcement of the access rights is necessary. However, current access control approaches based on the standard RBAC model or the extended ABAC model are still largely static, lacking the necessary dynamicity and flexibility required by virtual organizations (VO) for construction.



Generic approach to manage CAAC in a VO environment

Approach

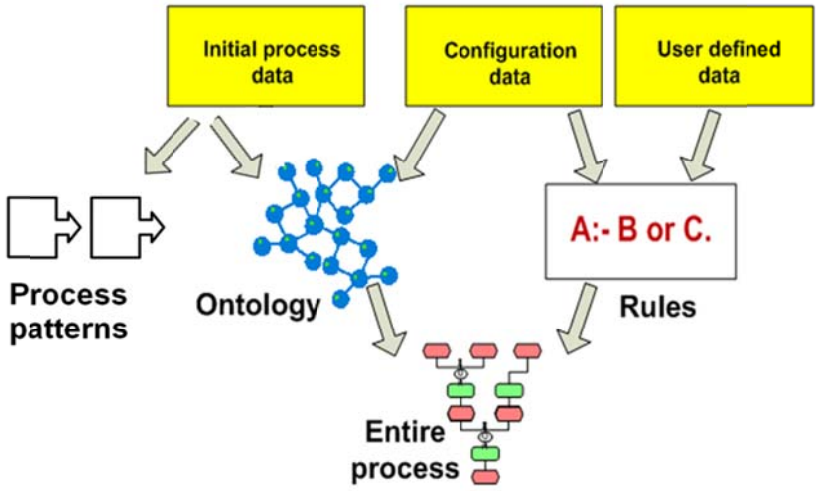
Typically, collaboration in VOs takes place on a Service Platform which regulates the access of the VO members (subjects) to the digital information resources and services (objects) representing dynamic real-world subjects and objects. As each project is a new collaboration between different companies, there is a need for a quick and easy configuration of VO's. Equally important is the possibility of a flexible reconfiguration of the VO if the participation of partner changes. The access rights may therefore depend on their current context situation and are changing in the course of processing. Possible context situations are described in a context model and depend on subject attributes, object attributes, process states and environment attributes. The workflow-processing and state transitions of object attributes are described by a process model. Hence, it is important in addition to the organizational model to include the context model and the process model in authorization decisions to determine the least set of privileges for each object in each situation. Based on a framework for Role Based Access Control in a service-oriented architecture (SOA), used in the project BauVOGrid, we will develop a solution that provides context-aware access control (CAAC) for VO platforms in order to achieve a highly flexible authorization mechanism capable of managing the least set of privileges for platform access in VOs in ICT environments. This research work is part of the mefisto project.

Ontology and Rule-Based Business Process Analysis and Planning

Ksenia Rybenko

Objectives

Construction companies are increasingly interested in describing and saving internal process knowledge in project neutral and modular form. This can be done with the help of process patterns or process modules that can be further used for fast and reliable process planning and analysis. As such, process patterns promote systematic reuse of proven or common practices. The hypothesis of this research is that an ontology knowledge base representing business process patterns with related construction data can provide a collaboration model with clear and unambiguous semantics, thereby facilitating integration and reuse of existing best practice business processes and data models. Formalization of the processes in ontologies and using ontologies within large projects with many heterogeneous resources has multiple advantages. By means of ontologies flexibility, interoperability and more efficient process management and analysis can be achieved. Today process planning is mainly done manually or at best on the level of IT supported scheduling. This requires a significant amount of work to create, adapt and maintain the business processes. An automated procedure realized by means of ontologies and enhanced with additional process rules can be much more effective, enabling the combination of a set of adapted process patterns into a consistent higher order process.



Principal business process analysis and planning by means of patterns (modules), ontologies and rules

Approach

In the Semantic Web's layered structure, it is still an open question whether or not there should be only one homogeneous hierarchy for using rules together with ontologies. However, a clear benefit of using rules with an ontology is the ability to close the domain at will and to succinctly represent knowledge that is not trivially expressible using only an ontology knowledge base. The construction process patterns, represented in one of the acknowledged process modeling languages (BPMN, EPC) can be beneficially formalized in an OWL ontology. Complex knowledge can be represented using the *drools planner* with its rule format. The formalization succeeds by using three kinds of data.

- *configuration data* that provides a set of non-ground rules defining the relationships between processes;
- *initial process data* that provides a set of ground facts defining what process patterns and construction data are available and what relationships they have with other processes and their data;
- *user defined data* that provides a set of ground facts telling what properties (or strategic values) the user wants the entire process to have.

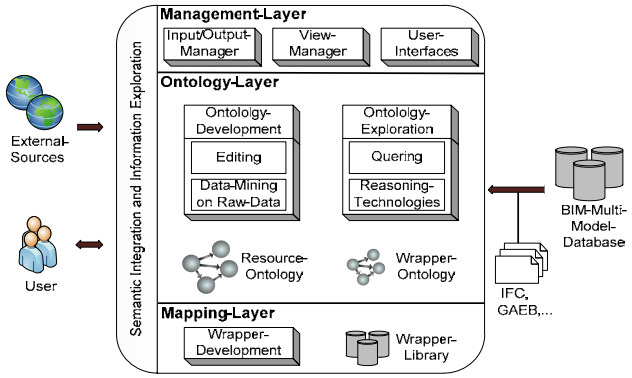
The prototype implementation is based on a Java framework which builds upon the described principal concepts. It will serve for dynamic process analysis and intelligent planning on the basis of process modules and will support process management by providing high-level reasoning capabilities. This research work is part of the mefisto project.

An Ontology-Based Semantic Integration of Multivariate Data for Civil Engineering

Mathias Kadolsky

Objectives

A variety of companies fail to cope with the vast amounts of data generated by applications for handling complex issues. Separating relevant information from irrelevant data, building and utilising knowledge are often insurmountable hurdles. In the scope of this work the focus is set on the development of solutions for the consolidation of data sets within the civil engineering sector. These data are produced during the overall value-added process of a constructional measure beginning with the design and planning work through the actual construction work. Thereby all digitally data gathered from applications for CAD, cost planning or others are contained in a BIM multi model container organizing them in sector-typical models. The objective of this work, therefore, is the development of a framework to filter out relevant information from these multivariate data containers and to embed this information in a specific semantic context of civil engineering by means of an ontology-based approach. The ontology creates the ideal foundation for exploring the information space with semantic methods. So, for instance, it is possible to validate planning processes in an automatic way and to verify, if a process step is in the correct order (e.g. concreting column follows reinforcing column).



Architecture of ontology-based integration system for multivariate data

Approach

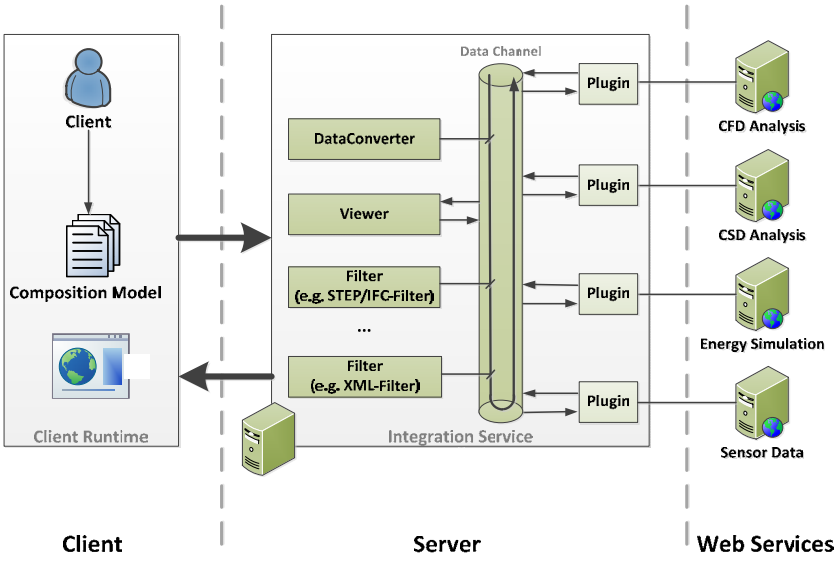
A system architecture divided into three layers is suggested. The partition comprises the management layer, the ontology layer and the mapping layer. On the management layer all functionalities are added serving the user through the interaction with the framework. These include an input/output-manager responsible for granting individual write and read rights, a view manager administrating any customer-centric view on the provisioned resources and services and obvious and intuitive interfaces allowing the user access to the system. The core of the system architecture is the ontology layer. All services are concentrated in this layer needed for the design and the exploration of civil engineering based ontology. Complementing the ontology design by hand there are data mining methods identifying ontology concepts and relations from the multivariate data set in an automated manner to support and to relieve the user comprehensively. In this context the possibility is offered to include external sources in the process of pattern recognition. For the targeted analysis of the ontology based information space instruments for effective querying and for deriving knowledge from a means are designed. These instruments are conceived in that way external libraries can be added and functionalities can be extended intuitively. The actual semantic integration of the different data - the mapping of the multi model data to ontology based structures - is achieved by various wrappers on the mapping layer. To support an individual in the development and in the subsequent implementation of a wrapper the underlying logic of mapping can be described in an ontology-based manner. Similarities to mapping logics of already implemented wrappers can be revealed and programming structures can be reused. The research work is part of the Trans-IND and the mefisto project.

A Flexible SOA for the Integration of Various Service Tools and Multi-Models

Ken Baumgärtel

Objectives

The usage of specific tools for monitoring building structures, with regard to energy efficiency or Computational Fluid Dynamics (CFD) solvers, leads to a more comprehensive Building Information Modeling (BIM) and a better Facility Management (FM). One problem here is the linking of each model like energy or fluid models with a concrete building model. In addition, there exists the need of choosing appropriate models for various cases. So it is possible to take an energy model to improve the FM, while it is more important to take a fluid model to compute the wind load of high-rise constructions. A service-oriented architecture (SOA) can help to solve these problems. Each tool uses a specific model, is provided by a web service and will be linked on a common platform. On the one hand it leads to an extensive functionality and the separation of concerns, but on the other hand it increases the size and complexity of shared data.



Principal system architecture

Approach

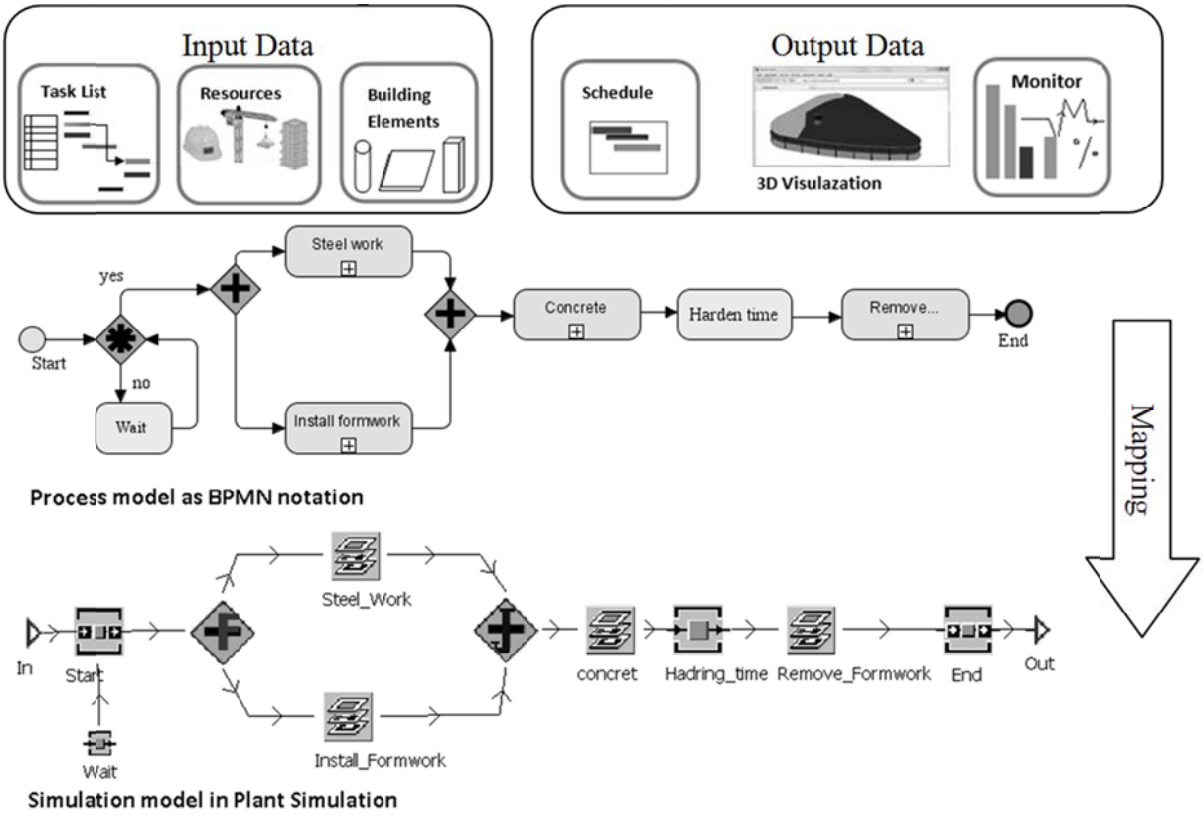
The system will be modular to embed each model dynamically. The exchangeability of a model improves the reusability of such a system in many cases. Furthermore, it is more homogeneous and uniform for facilitating the work of a user. The starting point is a composition model which will initialize the application. This model describes the usage, the linking and the arrangement of tools based on a declarative language. Each tool is integrated as a plug-in in the system and accessible by a web service. To achieve the communication of different loosely coupled plug-ins, the creation of multiple data channels will be provided. The structure and type of a data channel is dependent on the composition model, e.g. through a communication concept like the Publish/Subscribe principle, which allows a publisher to share data by firing events. One or more subscribers can listen to one data channel and must decide for themselves if they want to retrieve and handle the information. An example is a STEP physical file which can be filtered, linked with an energy model and visualized by a viewer in one application. Hence, the goal is to develop a comprehensive, consistent and powerful data concept for this SOA, which also allows the modification of published data, through filter or data converter easily. Finally, the application will be deployed as one holistic platform. This research work is performed in support of the EU projects SARA and HESMOS.

Rapid Deployment of Process-Based Simulation Models for Construction Projects

Ali Ismail

Objectives

The long time and the tedious efforts which are needed to create simulation models for each construction project is one of the important reasons which keep simulation techniques not widely used in practice till now. The high and complex dynamic aspects of construction operations beside the huge amount of necessary input information which come from different data resources (BIM, resource planning, project schedules, and other domain models) makes this task harder. This research is directed to develop automatic mapping methods from process to simulation models and develop appropriate simulation library to reduce the time needed to create simulation models for construction projects with the objective of high level of flexibility and ease of use. The developed library can be used during the planning phase as decision support tool to (1) improve the resources utilization, (2) validate and improve project schedules, (3) Analyze different "what if" scenarios and compare different construction strategies.



Approach

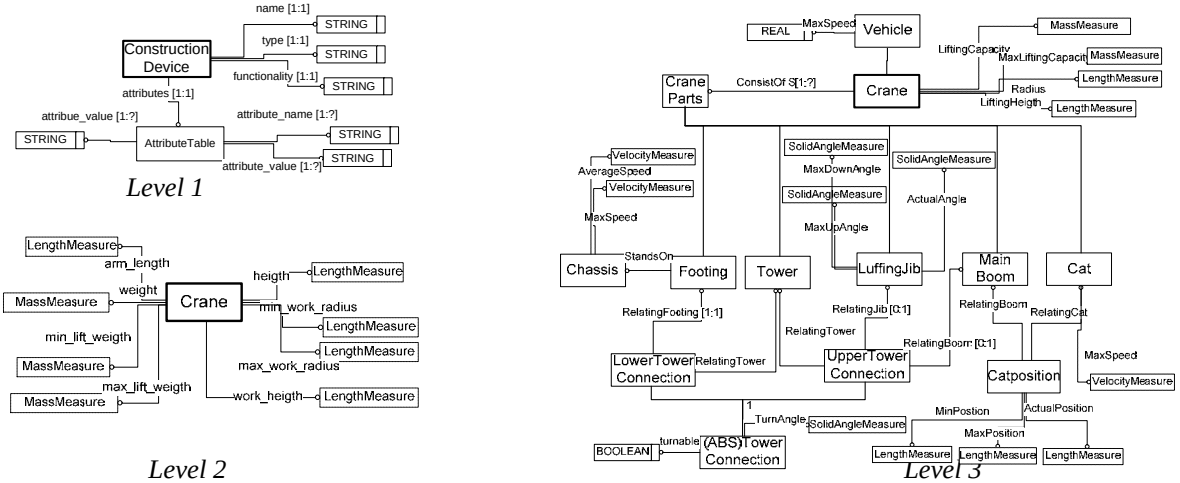
Process templates are used as central elements to describe the sequence, constraints and needed resources for construction operations. These templates can be created directly inside the simulation tool "Plant Simulation" or through mapping business process modelling objects into simulation objects as configurable and ready to use templates. The research focus on two main areas: (1) Mapping generic as well as sophisticated process modules of various construction operations into simulation modules, since working with BPMN diagrams is easier for people who are not specialized in simulation; BPMN provides a graphic representation of processes and the possibility to carry out changes of the process design and hence independent from the simulation environment. The automatic mapping will be done with help of an XML parser to map the basic elements of BPMN (task, join/fork gateway, sequence flow) into equivalent simulation elements made especially for this purpose. (2) develop new methods to break down the rough project schedules (e.g. floor and work section level) automatically by using process-based data filters to create fine detailed project schedules (single activities on building element level) as a part of the simulation input data. This research work is a part of mefisto project.

An Extensible Construction Site Model

Ulf Wagner

Objectives

One step for a better integrated and computer supported building project planning and realisation is, to be able to design a construction site with computer. But more than this it is necessary, to be able to interchange this plan digitally in a qualified information model enabling 3D, not only as a plain 2D file. At the moment there are a few catalogues for construction site equipment. The most important is supposable the Equipment-Information-System (EIS). This catalogue collects main public available information about equipment. EIS is a catalogue without 3D and semantic information. It is a decision helper for equipment choice. It is not designed for construction site design with work flow and collision examination. Therefore a dedicated 3D constructions site model is necessary. This model should provide information about construction equipment like product models for the building, including coordinates, shape and capacity, power and performance values. It should help the planer during process planning, equipment collision examination, animation and simulation of the construction site and give a functional description of the equipment.



Construction Site Equipment Model – Different Level of Detail

Approach

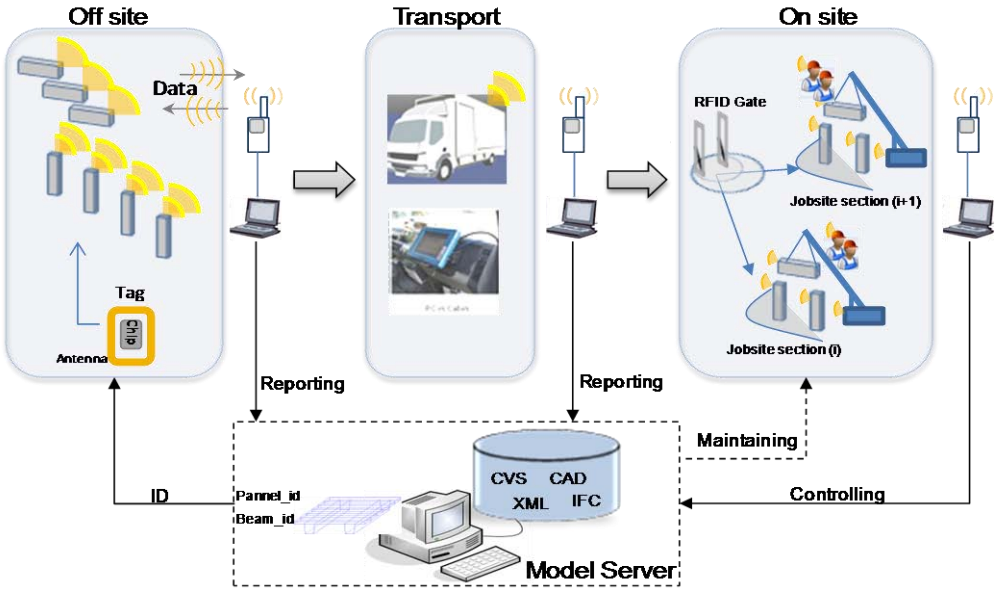
Not all information listed above can be brought together in one model. Such a model would be overloaded and difficultly to handle. The model should be seamless focusable on the essential features and attributes of the particular application. Additional features will be stored in other models (i.e. cost model) and ontologies (i.e. usage knowledge). The construction equipment model will be structured in different levels of detail and be focused to graphical representation, motion capabilities of main parts and important performance values for simulation and 3D animation. Beyond the scope of our model but extendable are: use and consumption of liquids like oil or fuel and sub parts like wheels or cables. The functionality of a gear is out of scope for construction site simulation, and only for a mechanical model interesting. Not directly in model stored, but in associated models and ontologies will be costs, detailed performance values, usage information and the building itself. The model will have three detail levels. On level 1 an object has a graphical representation and is distinct by its attributes. This level is mostly for compatibility with actual IFC-Standard and corresponding to IFC-Proxy. In Level 2 an object is specific, it has a graphical representation and simple attributes for the most important properties. Not all information will be stored in this three level model, but it will be linked with the information from EIS. The second level is designed for overviewing workflow simulations of construction site processes. In the third level construction equipment is described by its main parts as separate objects. A crane i.e. consists of footing, tower and jib. This level is needed for detailed animation and simulation with collision check. The next level would be a very detailed level with animated cogwheels and screws, but like mentioned above this may be out of scope for our purpose, but of course it is of interest for mechanics. For the compatibility between the levels a mapping will be defined, which works form higher to lower level automatically and in the other direction semi automatically with user support. This research work is part of the mefisto project.

Toward Applying RFID-Based System in Automating of Construction Process

Yaseen Srewil

Objectives

The Radio Frequently Identification technology (RFID) has been used for several years for different applications in different industrial fields. It has brought great benefits in these areas through improving real-time information visibility and traceability. However, less attention has been paid to the investigation of RFID technology in construction compared with other industries which is nevertheless considered an information-based industry in addition to its labour, material and capital intensive nature. Moreover, many current field practices at construction sites still rely on manual processes for asset tracking and information handling. Therefore, RFID technology provides the increased opportunities for automation and improvement in data acquisition and construction processes notably in prefabrication structural components delivery and on site assembly. The objectives of this research are to explore the potential applications of the RFID in spite of its future development and review the state of the art of using RFID technology in construction industry especially for FRP bridge composite components. Furthermore, this study will discuss a primary system for automated erection, on site assembly processes and resources management.



The concept system of embedded RFID technology in product identification in construction project

Approach

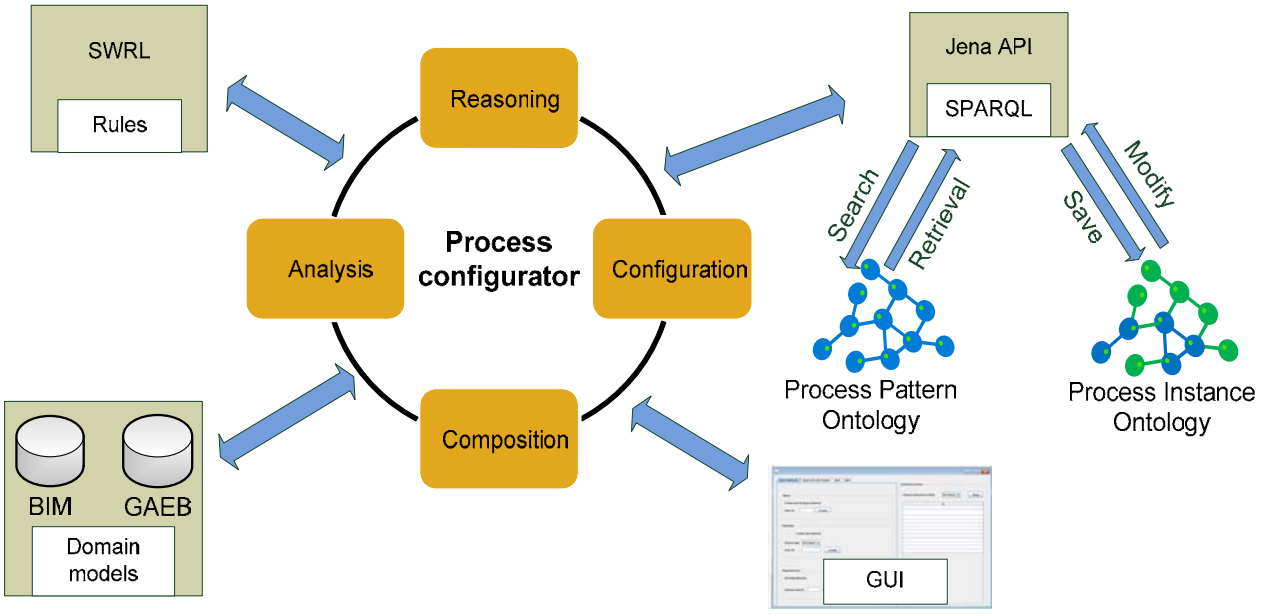
The start point of this research is exploring the recent developments of RFID technology in construction industry sector. One possibilities to apply RFID system for FRP bridges will be discussed since many of structural composite components are manufactured, delivered and installed on jobsite. It would be necessary to make sure that right components are procured and installed in time especially by considering the overlap of tasks in execution different bridge sections. Therefore, the data from different project phases (planning, scheduling, logistic and on-site installation components sequences) will be stored centrally in the system database (construction site model server). The system generated unique automatic identification (Auto-ID) for each component is written onto RFID tag. The (Auto-ID) and necessary data for each item can be captured by RFID reader/ writer. Meanwhile, a RFID reader will be installed at manufacturing site to register RFID tags and then tags information is synchronized to the server to change the status of element if any. Another reader is installed to tracking and tracing the components in the transportation phase. As soon as the components are arrived to the jobsite the RFID reader on the gate reads tags information and guide trucks/components to the right jobsite section and right device. In this case the gate of the construction site can allocate the resource according to the construction plans and installation schedules and call suit machine. The output information of construction site is applied as feedback to refine, develop RFID application and afterwards in maintenance of bridge. This research work is a part of the Trans-IND project.

Ontology-Based Configuration of Construction Processes Using Process Patterns

Alexander Benevolenskiy

Objectives

Modelling plays a significant role in representing and describing complex construction processes on more abstract level. Process modelling is used in construction to support various simulation tasks, but also to estimate and plan required resources and costs. A major problem is that due to the one-of-a-kind character of construction projects a lot of work is needed each time to manually develop a project's overall process schedule. However, the total individual process is typically structured in multiple stages containing a number of recurring similar sub-processes. Such sub-processes can be represented and stored as *generic reusable process patterns* that can be standardized and instantiated for many different projects and processes. The objective of this work is the development of a formal high-level model for construction processes and a methodology for using process patterns in the configuration and execution of complex construction tasks.



Ontology-based process configuration

Approach

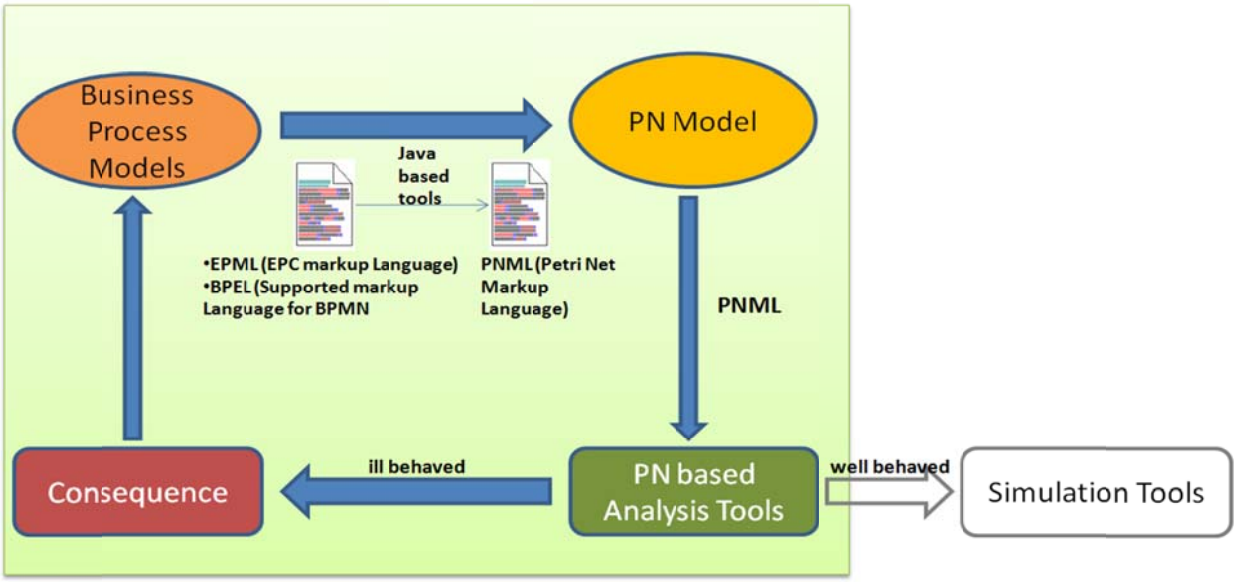
The main idea of the proposed approach is in the development and use of two separate but inter-related ontologies, i.e. (1) a *Process Pattern Ontology* and (2) a *Process Instance Ontology*, so that the process patterns from the first ontology can be used in many different construction processes represented by specific instantiations of the second ontology. Both ontologies are described by a common set of concepts in order to support their interaction. The Process Pattern Ontology stores typical process prototypes that can be used multiple times as predefined modules. Each pattern contains information about prerequisites that must be completed before performing the process. Additionally, added meta-data information allows searching for the patterns and filtering them using certain conditions. The Process Instance Ontology stores concrete process descriptions and is uniquely populated with specific process assertions for each construction case. The interaction between the ontologies is realized by a Java-based *Process Configurator*. In the configuration process the user searches for the available pattern modules in the Process Pattern Ontology and then uses these patterns to configure a specific construction process that will later be saved in the Process Instance Ontology. To work with the ontologies Jena (Open Source Semantic Web Framework for Java) is used. It provides a programmatic environment for RDF, RDFS and OWL and includes a rule-based inference engine. The models are queried through SPARQL, an RDF query language. Pattern retrieval is also realized with the help of SPARQL, enabling the dynamic binding of search attributes/concepts. This research work is part of the mefisto project.

Mapping of Business Process Models into Petri Nets for Construction Process Verification

Faikcan Koğ

Objectives

Construction projects consist of very complex and detailed processes, which are not easy to model or to integrate with each other. Even if there is a configured process model for a construction process, verification of the completeness and consistency of the system network is still a problem because of the complexity. Process modeling tools must support the process configuration with verification knowledge, which supports the end users to identify and to avoid system errors like deadlocks, etc. Existing tools are usually developed for Business Process Models (BPM) and they are not sufficiently suitable for the complex interaction of the construction process elements (like resources, time, etc.). Most common and effective tools of the Business Process Modeling are Event-Driven Process Chain (EPC) and Business Process Management Notation (BPMN), which have been invented for modeling business processes and hence are not useful to verify construction processes in a high level of complexity. The objective of this research is complementing the existing BPM tools with methods for verification of construction process models according to the behavioral and structural properties.



Automated Mapping of the BPMs into the Petri Nets

Approach

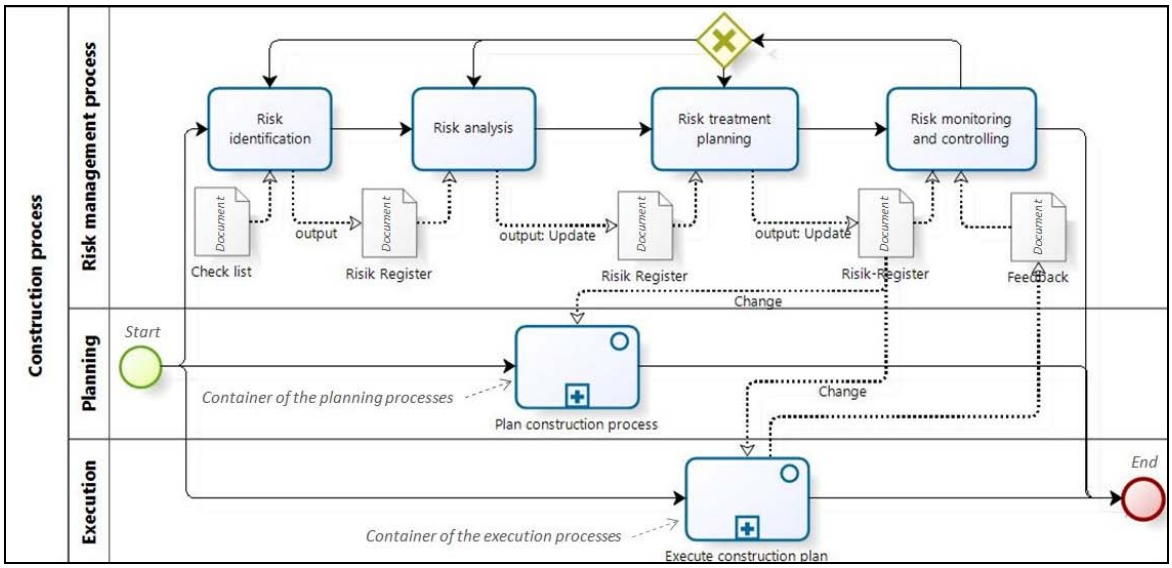
Petri Nets (PN), which is a mathematical and computational modeling language, is the selected method for the verification purpose. It gives system designers a capability of analyzing the models with matrix representations, and it allows modeling of concurrency, synchronization, and resource sharing behavior of a system. Therefore, BPM has to be mapped into PN in order to be able to investigate and verify the BPM. The mapping is developed from EPC and BPMN into PN. Our approach is to configure BPM and PN modules in such a way, that a 1:1 mapping between these modules is possible, thereby wrapping the n:m relationships in the modules. Some test mappings of BPM into PN for selected examples are already carried out using this approach. XSLT is used to automate the mapping and to represent models in a standardized schema, because it has capabilities for integration and transformation between different modeling languages, which are represented with XML (like EPML, BPEL and PNML). The PN model will be represented in PNML for handling in existing PN tools to analyze and to verify the properties of the model. In case of an ill-behaved model, the designer can introduce consequences and modify the process and check it again. In case of a well-behaved model, it is handed over directly to respective process simulation tools. P/T Nets (Place/Transition Nets - Low Level) will be used as a starting point of the research and extended later to High Level PN. The research will be further extended to the transformation of ontology represented construction process models into PN models too, to capture knowledge-based process modules developed by others. This research work is part of the mefisto project.

Integration of Risk Management in the Construction Process

Wael Sharmak

Objectives

Risk management should be an ongoing process for the whole lifecycle of a construction project. This can be ascribed to the facts that (1) construction projects are subjected to external risks more than other industries, and (2) the assumptions made in the planning phase of a construction project are based on incomplete information. This uncertainty in the planning data could lead to additional internal risks that appear late in the construction process and may even need reactive treatment to remedy their negative effects. Moreover, the identified risks may be overestimated or underestimated within the analyses, because the used evaluation data are uncertain. Risk management is an information demanding process in order to carry out the risk identification, analysis, and treatment planning tasks. The information can be classified to project-neutral and project-specific. The project-neutral information should be documented in a way that enables utilizing it in different projects in a context-sensitive way, while the project-specific information can be manually provided. For that reason, multiple connections between risk management and other construction process parts have to be established. For example, the risk treatment planning will demand changing one or more of the project plans to mitigate or even eliminate the negative consequences of risks. Moreover, within the execution phase of the project the risk monitoring and control task will continuously reevaluate the suitability of the planned treatment measures and will decide how to deal with new emerging risks. This shows that continuous and explicit activities (see fig) for capturing the correlations between risk management and other construction process parts are needed to enable an effective and appropriate risk treatment.



The interactions between risk management model and main construction phases

Approach

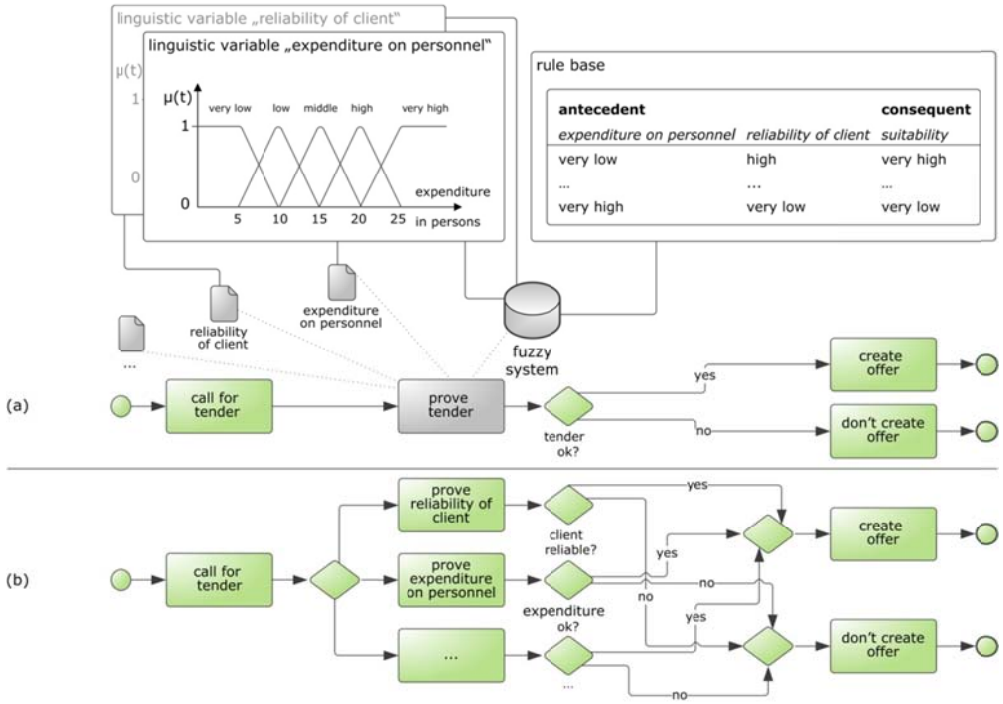
Project-neutral risk data are documented in a knowledge base that contains at least (1) risk description, (2) risk causes, (3) risk consequences, (4) a set of possible treatment strategies and (5) affected elements and processes. The knowledge base should be an ontological one to be context-sensitive and able to semi-automatically generate a risk checklist based on the specific context of the targeted project. The checklist is the start point for the project risk identification. It offers ready treatment solutions for the identified prioritized risks. As a risk treatment will demand the adjustment of the project plans, to keep the project objectives within the target constraints, suitable adjustment methods (e.g. predefined configurable modules) that integrate the treatment solutions in the targeted plans have to be developed. These changed plans are saved as new versions of the project plans. In this way, the development of the project can be tacked by comparing different versions and the change points can be documented. Moreover, chances and threats will be integrated by means of interoperability methods with the cost and schedule plans to adjust their estimation. The whole approach can help to speed up the planning and the adaptation of the construction plans. It will also help to study the effect of specific situations as What-If scenarios during the planning without endangering the success of the process objectives. This research work is part of the mefisto project.

Decision Making Using Uncertain Data and Information

Ulrike Schirwitz, Uwe Reuter

Objectives

Processes of the building industry are characterized by a large number of uncertain data. For well-founded decisions, e.g. in the context of treatment of risks, information processes or selection of suitable process modules, these uncertainties have to be regarded. The basis for human decisions is a multitude of criteria and rules, which mostly are not defined by crisp limits and which can compensate each other. Experts are able to handle these complex structures because of their experiences. However, a computational support is more transparently and can be applied at any time even by non-experts for standard cases. Hence, the expert knowledge is archived permanently and also can be expanded. The objective is to realize an efficient fuzzy decision support system which delivers in consideration of uncertainty more realistic or rather humanlike results than a deterministic expert system. It should enable the input of the knowledge by the experts themselves and the integration in different fields of application. Using such a system is practical especially for frequently recurring decisions with different input values and clearly distinguishable possibilities.



Process model with integrated epistemic uncertainty (a) and without consideration of uncertainty (b)

Approach

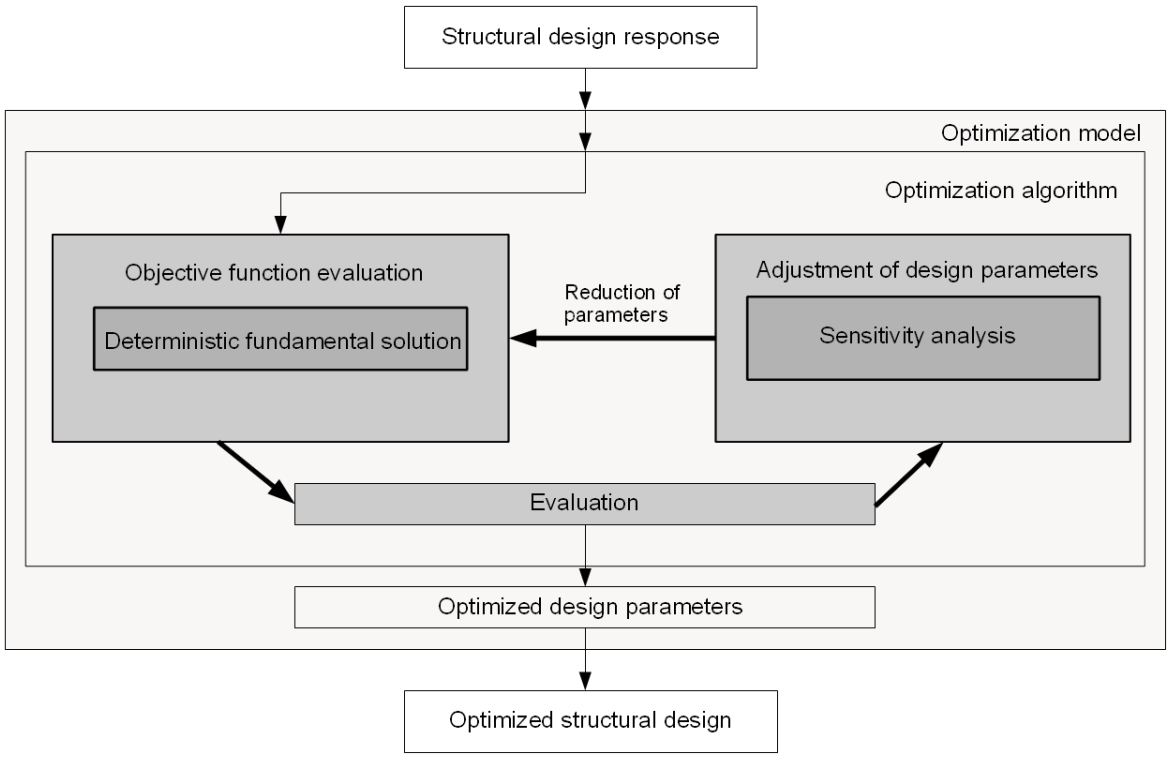
Due to the absence of complete knowledge in the case of epistemic uncertainty or rather fuzziness, it is impossible or at least costly to describe a single data or information exactly. Fuzzy set theory is applicable for modelling epistemic uncertainty to avoid unrealistic results. It enables the mathematical processing of rules which can be formulated only uncertain. That means human knowledge can be formalized in a way that computational supporting is possible and artificial averaging can be avoided. Therefore, linguistic variables will be used to formulate decision rules. Fuzzy logic as a multi-valued logic can be applied amongst others for creating a decision support system. The figure above exemplarily shows a process with two possible end events. In the upper part (a) epistemic uncertainty is integrated. Thereby, the main process is presented in the model more clearly than in the standard process model (b): the decision process with its details is extracted into a second layer – the fuzzy system. This fuzzy system enables to simulate a more humanlike decision process because of the integration of existing uncertainty. Therefore, "softer" transitions and the compensation of several rules are possible in contrast to deterministic decision support systems. Fuzzy decision support systems work in three phases: (I) Fuzzification, (II) Inference and (III) Defuzzification. Depending on the field of application suitable methods for (II) and (III) have to be identified. A restriction of permitted types of membership functions can simplify operation. This research work is part of the mefisto project.

Global Sensitivity Analysis for the Efficient Solution of Optimization Problem in Design Process

Zeeshan Mehmood, Uwe Reuter

Objectives

Optimization of a structural design is a computationally extensive process. The response of a structural model is subjected to an optimization process. During the optimization process, the objective function which is formulated on the basis of the model response is analysed depending on the design parameters and constraints. Thus the optimization model is often dependent in part on the number of design parameters. The complexity of the optimization problem can be reduced if the relationship between the design parameters and the model response is effectively identified. This relationship is captured by the methods of sensitivity analysis. Sensitivity analysis helps in identifying the most significant model parameters affecting a specific model response. In case of a non-linear design model, global sensitivity analysis can identify the relation between input parameters and response parameters. The objective of this research is to evaluate and develop methods for the sensitivity analysis of non-linear models in order to facilitate the optimization of a structural design.



Structural design optimization using sensitivity analysis

Approach

Already existing variance based sensitivity analysis techniques such as ANOVA and SOBOL indices provide sensitivity information for linear and simple non-linear models respectively. These sophisticated sensitivity approaches provide results in a computationally expensive manner which hinders the industry relevant application. In this research, properties of certain meta-models or functional approximation techniques are exploited for extracting sensitivity information. Meta-models might capture the non-linear relationships of the underlying input parameters to the design response. The sensitivity is assessed by means of measures capitalizing diverse properties of these models. Sensitivity analysis with meta-models is likely to be less computationally expensive and can be easily applied to the relevant industry problems. This research work is part of the EGSA project.

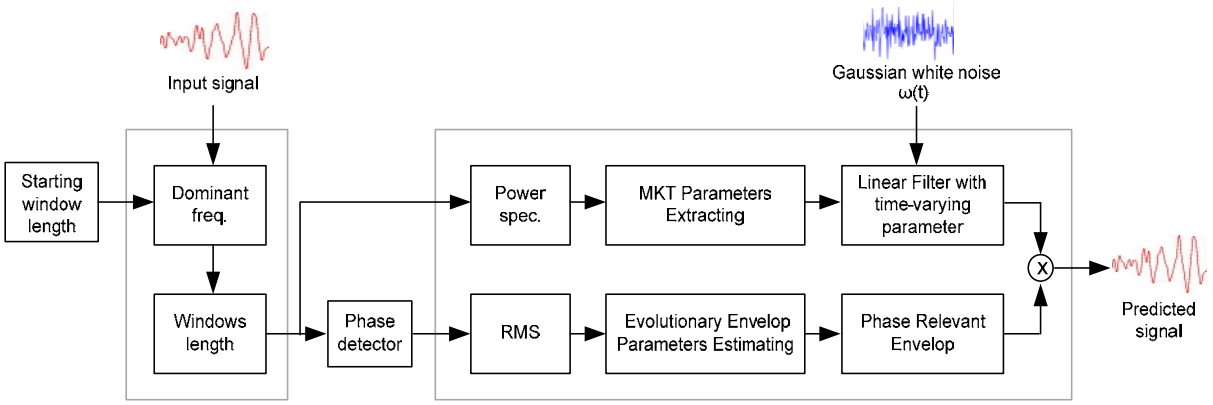
A Stochastic Real-time Wave-type Based Model for Prediction of Strong Ground Motion Accelerogram

Amin Zahédi Khaméneh

Objectives

A wave type based method for real-time prediction of strong ground motion (SGM) accelerogram is developed. Real-time prediction of SGM is requested in predictive building control systems to compensate the time delay, which occurs during processing of measured information and in executing the control forces. The time delay might cause unsynchronized application of the control forces and this unsynchronization can not only render the control ineffective, but may also cause instability in the system.

It is well known that SGM is a classic example of non-stationary stochastic process with temporal variation of both amplitude and frequency characteristics. In the suggested real-time predictor the non-stationarity is achieved by splitting the process in its dominant phases, namely P, S and coda. Additionally, separating the temporal amplitude and spectral non-stationary characteristics of the process increases flexibility and ease in modeling and parameter estimation. The temporal stochastic evolutionary process of amplitude is modeled by using an exponential wave type based envelope function which was suggested by Shinozuka and Sato. In order to model spectral amplification of several layers and/or modes of resonance, multi Kanai-Tajimi filter (multi-KTF) proposed by Bretschneider and Scherer is used.



The components of the stochastic real-time predictor

Approach

In order to detect the dominant phase a stochastic principal component based model which was developed by Scherer et al is used. It is shown that changing of the angle between the first stochastic principal component and the vertical axes in a Cartesian coordinate system can illustrate reliably changing of dominant seismic wave phase. The real-time predictor model parameters will be identified by matching the model to the target accelerograms. The envelope function described through three parameters which are related to variables that directly present the physical properties of an accelerogram. The parameters of the amplitude envelope are estimated by using the rising gradient and upon availability position of the envelopes peak. The dependency between envelope rising gradient and the position of peak value is modeled by use of stochastic artificial neural networks. Performance of the proposed model is verified by the use of strong ground motion records of Northridge (1994), which are selected upon the soil types of C and D according to Eurocode 8. The most significance of the proposed model is the concept of wave type based modeling which has the advantage of a conceptual physical modeling of the seismic process furthermore in spite of the common non-stationary modeling methods, which has a single envelope function, the suggested SGM predictor model is extended to the most important wave types which more precisely reflect non-stationarity of seismic process as well as in time and in frequency domains.

Research Contracts

Title:	**mefisto – A model, information and knowledge management platform in AEC** *(mefisto – Eine Modell-, Informations- und Wissensplattform im Bauwesen)* www.mefisto-bau.de
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. P. Katranuschkov, MSc S.-E. Schapke
Financial Support:	BMBF (German Ministry of Education and Research)
Budget/Funding:	16.1 million Euro/9.4 million Euro (total), 1.5 million Euro (CIB)
Duration:	3 years, since 4/2009
Approach:	mefisto is a BMBF lead project in construction ICT that aims at developing a framework and a visual platform for the management of the multi-model world of construction projects based on a process-centric approach. It defines a structured set of information models subdivided into several layers with regard to the represented information (1: building product, building site, building organisation, 2: work grouping, schedules, costs, 3: risks and uncertainties, 4: several ontologies). Interoperability of the modelling data will be achieved via a common platform ontology, the developed mefisto container concept, capturing various process-related views, and a set of interoperability services achieving the needed filtering and mapping data transformations both horizontally (between different models on one and the same level of abstraction) and vertically (to/from the different levels of abstraction within one model schema, thereby enabling appropriate information aggregation and expansion). These interoperability services will be embedded in an overarching process management approach providing for dynamic definition and run-time application of process modules on the basis of reusable reference process patterns incorporating compositional, contextual and strategic knowledge. Using these newly developed services as well as available sophisticated systems for construction management, controlling, geometry modelling and simulation, which will be extended in the frames of the project, mefisto will achieve: • Flexible and efficient construction site configuration • Process representation and information views on different levels of granularity • Semi-automatic creation of simulation model so that simulation tasks can become affordable not only to large-scale projects • Semi-automatic conflict detection by various logistics and construction tasks • Prognosis and risk management • Integrated controlling and management, bridging the gap between contractor and client but at the same time observing contractual and security constraints. From ICT point of view the overall system will be an open, distributed modelling and service framework enabling plugging-in of third-party tools both locally, as extension of available systems, and centrally, as commonly accessible web services. Special attention will be paid to the development of various innovative visualisation techniques to enable efficient navigation and examination of different aspects of the multi-model project world, such as 4D and 5D viewing/navigation, topological views, cockpit functionality for display of critical values and visualizations of abstract networks resulting from costs, time, risks, and other interdependent models etc.
Partners:	TU Dresden, Institut für Bauinformatik – **Coordinator**, AEC3 Deutschland GmbH (München), Ed. Züblin AG (Stuttgart), gibGREINER GmbH (München), Max Bögl Bauservice GmbH (Neumarkt), RIB Software AG (Stuttgart), SimPlan AG (Maintal), Solidpro GmbH (Langenau), TU Dresden: Institut für Baubetriebswesen, Institut für Software- und Multimediatechnik, Bauhaus-Universität Weimar: Professur Baubetrieb und Bauverfahren, Ruhr-Universität Bochum: Inst. für Informatik im Bauwesen

Title:	**HESMOS – ICT platform for holistic energy efficiency simulation and lifecycle management of public use facilities** www.hesmos.eu
Project Leader:	Prof. Dr.-Ing. R. J. Scherer, Co-leader: Dr.-Ing. Peter Katranuschkov
Financial Support:	EU – EC FP7, EeB.ICT.2010.10-2 – ICT for energy-efficient buildings and spaces of public use
Budget/Funding:	4.6 million Euro/2.7 million Euro (total), 0.6 million Euro (CIB)
Duration:	3 years, since 9/2010
Approach:	HESMOS develops an industry-driven holistic approach for sustainable optimisation of energy performance and emissions (CO2) reduction through integrated design and simulation, while balancing investment, maintenance and reinvestment costs. The objective is to close the gaps between existing intelligent building/facilities data so that complex lifecycle simulation can easily be done in all design, refurbishment and retrofitting phases where the largest energy saving potentials exist. This will be achieved by (1) extending the existing standard Building Information Model (BIM), energy simulation and cost calculation tools, so that they can seamlessly exchange the required data, (2) integrating advanced energy simulation tools into the design and FM process, so that BIM-CAD and FM tools can be used as building energy simulators and gap identifiers, (3) developing new applications that can visualize building performance in easy to understand way and can quickly display impacts of changed building/space parameters, (4) developing new "cockpit functionality" in BIM-CAD on EPBD basis to provide fast feedback of the impact of design parameters on lifecycle energy performance, (5) extending BIM-CAD to model and manage buildings and surrounding areas, and (6) integrating BIM and Building Automation System data and querying these multi-model data with the help of a high-level easy to understand engineering language. The product of HESMOS will be an Integrated Virtual Energy Laboratory (IVEL) enabling comprehensive studies of design and retrofitting alternatives concerning energy performance and total costs. An innovative SOA around the kernel functionality of BIM-based CAD/FM will be applied. Information interoperability will be achieved by enhancing BIM with energy and emissions features to a new sharable eeBIM. Intelligent access methods and a specialised ontology will be developed to enable multi-system integration and management of material, climate and product databases and data from sensor networks and other ICT sub-systems into CAD/FM. An extensive 30-month validation program at two PPP projects will be carried out during the project.
Partners:	TU Dresden, Institut für Bauinformatik – **Coordinator**, Nemetschek Slovensko s.r.o. (Slovakia), Olof Granlund Oy (Finland), BAM Utiliteitsbouw n.v. (The Netherlands), BAM Deutschland AG (Stuttgart), Obermeyer Planen + Beraten GmbH (München), AEC3 Ltd. (UK), TU Dresden: Institut für Angewandte Informatik, Institut für Bauklimatik

Title:	**Trans-IND – New industrialised construction process for transport infrastructures based on polymer composite components** www.trans-ind.eu
Project Leader:	Prof. Dr.-Ing. R. J. Scherer
Financial Support:	EU – EC FP7, GA NMP2-LA-2009-229142
Budget/Funding:	9.8 million Euro/6.1 million Euro (total), 0.2 million Euro (CIB)
Duration:	4 years, since 6/2009
Approach:	Polymer based manufactured components for construction applications have been designed, developed and demonstrated in several European projects such as HP FUTURE-Bridge, SAFEFLOOR and MEGAWIND. The findings of these projects have been very promising with regard to customer requirements, quality, technical and economic feasibility and the favourable impact of using this kind of composite-based components in terms of sustainability, safety and quality of life. However, there is still a need to industrialise the whole construction process of the Fibre Reinforced Polymers (FRP) components in order to achieve real practice results. Furthermore, integration of the entire supply and value chain is needed, as well as the development of a high technology for design and manufacturing of FRP components, to transform on-site construction to off-site manufacturing. To answer such challenges the European Integrated Project Trans-IND sets out to develop a *cost-effective integrated construction process* based on innovative product and process management methods that will enable the maximum capability of industrialisation of components for transport infrastructures such as road and pedestrian bridges, underpasses, acoustic and safety barriers using polymer based materials (carbon fibre, glass fibre). The project outcomes will be demonstrated, as a pilot case, for components of a bridge (beams, preslabs) due to the high complexity in the bridge components manufacturing and assembly compared to other applications.
Partners:	Mostostal Warszawa S.A. (Poland) – **Coordinator**, Acciona Infraestructuras S.A. (Spain), Advanced Composites Group Ltd. (UK), ASM Centrum Badan i Analiz Rynku Sp. z o.o. (Poland), D'Appolonia S.p.A. (Italy), Fundacion Fatronik (Spain), Fraunhofer-Institut für Produktionstechnik und Automatisierung IPA (Germany), Huntsman Advanced Materials GmbH (Switzerland), Consiglio Nazionale delle Ricerche (Italy); Institut für Verbundwerkstoffe GmbH (Germany), Labein Tecnalia (Spain), MIKROSAM (FYR Macedonia); Semantic Systems S.L. (Spain), TNO (Netherlands), BV machinefabriek van Wees Tilburg (The Netherlands), Universita Politecnica delle Marche (Italy), Gradbeni Institut ZRMK d.o.o. (Slovenia), Solintel M&P S.L. (Spain), Atos Origin S.A.E. (Spain), TU Dresden – Institut für Bauinformatik (Dresden, Germany)

Title:	**SARA – Coupled structural/aerodynamic analysis and control of wind-induced loads on civil engineering structures** *(Gekoppelte Fluid-Struktur-Analyse und -Kontrolle windinduzierter Lasten auf Bauwerke des Ingenieur- und Hochbaus)*
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. Peter Katranuschkov
Financial Support:	EU – Eurostars Nr. E14797; BMBF (German Ministry of Education and Research)
Budget/Funding::	1.3 million Euro/.9 million Euro (total), 0.3 million Euro (CIB)
Duration:	3 years, since 3/2010
Approach:	Accounting for the wind-induced loads on a structure, Eurocode 1 regulations (EC1) are routinely used by commercial structural analysis software. However, in the case of artistic architectural designs involving complex building shapes, EC1 provides only rough approximations. It goes through the use of very general assumptions, since it mainly refers to applications with simple geometries. In addition, only integrated loads on structures can be obtained, but not load distributions. Whenever accurate and detailed calculations are needed for the wind-induced loads to the structure, costly experimental studies in wind tunnels have to be performed. Consequently, in order to make informed design decisions a large number of models with various sets of parameters have to be tested. Hence, what happens by routine designs is that the structure is often over-dimensioned by means of qualitative and/or heuristic use of EC1 guidelines. However, in the case of elastic structures, over-dimensioning against static loading does not guarantee their safety against extreme, dynamically varying real wind loads. The innovation of the SARA project lies in (1) the use of a real Building Information Model (BIM) from design, (2) the semi-automatic generation of the structural analysis and dynamic wind loading models, (3) a numerical tool for the simulation and calculation of the structure's response to wind-induced loads, and (4) a BIM management system for the handling of model variations and simulations. Special emphasis will be put on the case of tall buildings where wind phenomena are most important. The product of the research will stand for "numerical wind tunnel", where possible modifications during the design stages can be easily and without costs incorporated into the structural model, load distributions can be obtained along the structural members, and elastic structures of arbitrary geometrical complexity can be analysed. Furthermore, the proposed methods will be applicable for the assessment of mechanisms and shape design techniques aiming to control wind-induced vibration and improve the performance of tall buildings to it. Thus, the impact of wind-induced loads to the architectural design, as well as measures to alleviate undesired building responses, can be incorporated in everyday design work, replacing for most design stages the costly wind tunnel experiments.
Partners:	SOFiSTiK Hellas S.A. (Athens, Greece) – **Coordinator**; Wacker Bauwerksaerodynamik GmbH (Birkenfeld, Germany); TU Dresden – Institut für Bauinformatik (Dresden, Germany)

Title:	**GeoTechControl – Knowledge-based service platform for monitoring and prognosis of the behaviour of geotechnical engineering structures** *(GeoTechControl – Wissensbasierte Serviceplattform für Überwachung und Prognose Geotechnischer Ingenieurbauwerke)*
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Gerald Faschingbauer
Financial Support:	BMBF (German Ministry of Education and Research)
Budget/Funding::	1.7 million Euro/1.1 million Euro (total), 0.3 million Euro (CIB)
Duration:	3 years, since 7/2010
Approach:	Due to the high uncertainty of the underlying geotechnical models complex construction activities in geotechnical engineering typically require continuous monitoring, frequent adjustment of prediction calculations to the measured actual system behaviour and flexible situation-dependent management of the construction process. To answer that challenge GeoTechControl develops an innovative monitoring and prediction system that will raise significantly the safety and the economic efficiency of geotechnical engineering works by means of a synchronised construction and monitoring process cycle. The use of advanced Web 2.0 technologies will enable continuous performance of semi-automatic system identification to fill in the current gap between sensor data acquisition and their proper just-in-time engineering interpretation. A new system identification method, namely simulation-based system identification will be developed, which demands a knowledge-based representation of the total ICT system to reach automatic generation and control of the simulation cases. Continuously gathered sensor data will be applied for simulation and knowledge based adjustment of the geotechnical models used for proper identification of the actual system behaviour. The parallel evaluation of multiple model candidates using distributed computational and storage resources in a controlled overall workflow will help to minimize total analysis time, enabling the currently impossible feedback between measurements and prognosis. This will provide for purposeful and timely cause-effect diagnosis by occurring differences between as-designed and as-measured data. The improved prediction computations achieved on that basis will enable derivation of reliable control parameters for automated construction processes as well as informed decisions about corrective actions in manually managed construction activities. Hence, GeoTechControl will provide for substantially minimized risks in large geotechnical undertakings.
Partners:	FIDES DV-Partner GmbH (München) – **Coordinator**; Zerna Ingenieure GmbH (Bochum); ELE Beratende Ingenieure GmbH Erdbaulaboratorium (Essen); Bilfinger Berger Ingenieurbau GmbH (Wiesbaden); Keller Holding GmbH (Offenbach); GeTec Ingenieurgesellschaft für Informations- und Planungstechnologie mbH (Aachen); TU Dresden: Institut für Bauinformatik, Institut für Geotechnik

Title:	**eWorkBau – Webservice-based multi-media teaching and learning concept for craftspeople's training in mobile model-based working methods** *(eWorkBau – Webservice-basiertes multimediales Lehr-/Lernkonzept für die bauhandwerkliche Aus- und Weiterbildung für die mobile modellbasierte Arbeitsweise)*
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Gerald Faschingbauer
Financial Support:	BMBF (German Ministry of Education and Research)
Budget/Funding:	1.8 million Euro/1.6 million Euro (total), 0.5 million Euro (CIB)
Duration:	3 years, expected start 3/2011 (approved stage one of the proposal, contract negotiations in progress)
Approach:	The objective of eWorkBau is the development, testing and field trial of an innovative learning concept for construction craftsmen, encompassing the intensive use of new media and educational methods in the new area of mobile, model-based working. It will enable online participation in virtual classrooms, synchronous learning in Blogs, electronic forums and expert knowledge platforms using Web 2.0 technologies. The aim is to prepare German construction craftsmen for the paradigm shift towards model-based working, thereby providing for sustainable growth and competitive advantage of the sector. The overall approach will be developed by the academic partners, supported by experienced workers and trainers from practice. It will be tested on a number of typical practice scenarios. The expected outcome is a Multimedia Learning Concept that enables the acquisition of advanced problem solving and decision making knowledge and skills, grounded on mobile communication and model-based cooperation techniques. Selected software tools will be adapted and extended by pedagogical aspects to provide for enhanced understanding of the educational goals. Focused is especially the work with a BIM database for craftsmen using mobile devices to prepare bidding proposals, bidding calculations, cost calculations and work schedules and to perform efficient progress monitoring and resource planning. The craftsmen participating in the program will acquire knowledge and skills enabling them to use advanced filtering methods and tools to read and extract specific data from BIM-CAD software, as suitable for their purposes. They will be capable of creating a simplified BIM-based model of a construction site, fill it in with information related to their specific tasks and structure their work accordingly, in an efficient goal-oriented manner.
Partners:	Interessengemeinschaft des Heinz-Piest-Instituts an der Leibniz-Universität Hannover e.V. – **Coordinator**; AEC3 Deutschland GmbH (München); Dachdeckermeister Claus Dittrich GmbH & Co KG (Dresden); Handwerkskammer Koblenz; Handwerkskammer Münster; Zentralstelle für die Weiterbildung im Handwerk Düsseldorf; TU Dresden: Institut für Bauinformatik, Professur Psychologie des Lehrens und Lernens

Title:	**EGSA – Evaluation and development of methods for efficient global sensitivity analysis in design process and their realization with an innovative software prototype** *(Erforschung und Entwicklung von Methoden zur effizienten globalen Sensitivitäts-analyse als Grundlage eines innovativen Software-Prototypens im Entwurfsprozess)*
Project Leader:	Dr.-Ing. habil. U. Reuter
Financial Support:	European Union (EFRE); Free State of Saxony (SAB)
Duration:	20 month, since 10/2010
Approach:	The optimal design of a vehicle for crash load cases requires consideration of a variety of criteria (design goals), e.g. injury criteria of the passenger and the pedestrian protection, repair costs due to a slow speed collision or partner protection (collision with other vehicles). The simultaneous consideration of different opposite design goals for different load cases (crash scenarios) leads to a very complex multi-layered process. A design engineer has many parameters (theoretically unlimited) to consider in order to achieve an optimal design. Many individual components e.g. geometry (overlapping shapes, cross-sectional shapes, ...), material (strength, yield strength, formability, weldability, ...), parameters of passive safety systems (trigger times of airbags and belt tension systems, sensors, seats, ...) must be determined simultaneously. For the solution of design problems, numerical simulation is often used in addition to the experience based methods. Conditions for the numerical optimization are realistic and therefore very complex mathematical models are inevitable. The numerical and experience-based optimization is in essence an analysis of variants. Every variant of a computational model, which is investigated, represents a possible combination of available parameters. The number of variants to be tested depends mainly on the number of parameters and lies in between more than 10 000 per vehicle project. The calculation time needed to evaluate only a single variant on a high performance computer lies in the range of several hours to days. The use of large computational models and very large number of parameters in practice leads to a dilemma. A simplification of the computational model is not possible because a realistic depiction of the crash process is necessary. The (arbitrary) reduction of the number of parameters leads to a poor utilization of the actually existing optimization potential in the vehicle development. The resolution of this dilemma is possible by reducing the number of possible design parameters to significant parameters, i.e. the parameters which significantly affect the design goals. The identification of these significant parameters is not trivial and can only be possible by using methods of sensitivity analysis. Existing methods and algorithms have major drawbacks as well. They are either fundamentally not adequate for complex, non-linear problems (like crash-interpretation of a vehicle) or their use implies a non-viable computational effort. The objective of this project is to research and develop methods for global sensitivity analysis of non-linear models in the simulation and preparatory studies for subsequent implementation of an innovative software prototype.
Partners:	DYNAmore GmbH Dresden – **Co-ordinator** TU Dresden – Institut für Bauinformatik, Faculty's Computing Centre (IT Lab)

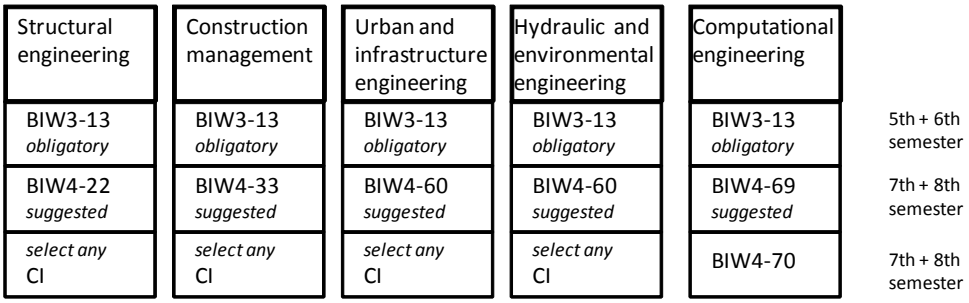
Title:	**Campus-Navigator – The guidance system of the TU Dresden**
Project Leader:	Dr.-Ing. Uwe Reuter
Financial Support:	TU Dresden
Duration:	Since 2001
Approach:	Room-related digital data of buildings belonging to the TU Dresden campus are collected by the administration of the TU Dresden. The Campus Navigator summarizes these data as an externally working system and provides employees, students and visitors these data in a textual and graphical way on an interactive web site. All relevant information stored in the university's CAFM system KOPERNIKUS, using an ORACLE database, can be accessed that way. The software visualizes floor and orientation plans in real time out of the stored data by transforming them into vector graphics in the SVG format, which finally can be displayed in web browsers, for instance via the ADOBE SVG plug-in. Linking and visualizing of the graphical and textual data is based on XML. Via a self-managed ORACLE database, specifically created HTML pages for disabled persons are integrated. Besides the automatic synchronization with the administration databases the content of the curriculum timetables is also provided. With special attention to disabled or mobility restricted persons a routing system (routing through the campus) based on the A-star-algorithm has been developed, which is supported by a parsing process that augments the existing CAD-data with the necessary semantics. The benefits of the system include the collection of information from a diversity of data sources, their transformation, graphical rendering and especially the deployment in existing and established networks and end-user environments.

Lecture Activities

Since 2006 the students can choose construction informatics as a competence feature in their curriculum. This means that in the 4-semester Diploma course, starting with two preparatory lectures two semesters before, students can choose construction informatics as a second subject. As the main subject, Diploma courses are offered for (1) structural engineering, (2) construction management, (3) urban engineering, infrastructure and transportation engineering, (4) hydraulic and environmental engineering and (5) computational engineering. Studies in the Diploma course are organized in modules of 6 hours a week yielding in 5 credit points. The 4 semesters include a project work in the 3rd semester and the Diploma thesis in the 4th semester. Both can be done in construction informatics. As construction informatics has to be a complementary subject a pool of 5 modules is offered to the students in order to allow them complementing their basic studies in an optimal and individual way. One of the 5 modules is mandatory, namely WP3-13 "Construction Informatics – Fundamentals", whereas the other two can be chosen out off the remaining four (WP4-XX). Each of the 4 modules is preferably aligned to one of the Diploma courses, which is indicated by intended audience of the course.

Structogram on construction informatics (CI) in the civil engineering curriculum

Diploma/Master course if construction informatics competence is chosen



Module BIW1-07: Construction Informatics Fundamentals

Intended Audience: Main courses of civil engineering (1st and 2nd semester)
Duration: 2 semesters
Lectures and Tutorials: Scherer/Wülfing

Subjects: This module, comprising two courses, provides basic knowledge about algorithms and data structures as well as their modular implementation in an integrated software system. The relational and the object-oriented modelling and programming approaches and the definition and generation of specific views (such as geometrical, topological and graphical representations) are explained on the basis of real AEC objects. The students obtain the ability to think 'object-oriented' in order to structure complex problems modularly and develop generalised modular solutions using algorithms and data structures adequately, with due consideration of their dual and complementary nature. They acquire the capability to formally specify and perform selective, focused modifications as well as further extensions to existing software systems using available software libraries. The module is configured as an e-learning module with object-oriented e-learning tools.

Module BIW2-09: Information Management and Numerical Mathematics

Intended Audience:	Main courses of civil engineering (5th and 6th semester)
Duration:	2 semesters
Lectures and Tutorials:	Scherer, Reuter/ Windisch, Reuter

Subjects: The two courses of this module enable the acquisition of knowledge about the basic methods and procedures from the domains of numerical mathematics and information management that are used for the solution of engineering and economic problems in AEC. The students obtain knowledge about principal solution algorithms for linear equation systems and skills in the handling of matrix methods as well as approximation and interpolation techniques, especially using Spline Methods. They learn the fundamentals of Building Product Models and their object-oriented representation which is especially useful for tackling the complexity and heterogeneity of the information resources in construction, the resulting distributed modular data structuring and the related interoperability methods. Basic techniques for the structuring and the formalisation of complex engineering information are presented that empower the students to handle the complex information used in AEC software in such way that it can be efficiently communicated within cooperative design and project management processes.

Module BIW2-15: System- and Information Modelling

Intended Audience:	Main courses of civil engineering (6th semester)
Duration:	1 semester
Lectures and Tutorials:	Scherer/Windisch

Subjects: The module introduces into system modelling with focus on the information flow and information logistics. Basic modelling languages like IDEF0 and EXPRESS are shown. The focus is put on the modelling of sub-systems, on aggregation and on complex relationships of the sub-systems. The students should acquire competence to model the complex energy system of buildings on different levels of granularity as well as in separate sub-systems, and synthesize these to a total system, thereby properly describing the building and the energy system both as a whole and as their parts like the solar sub-system, the building envelop, the sensor system, the building usage or the user profiles in the frame of the overall building life-cycle.

Module BIW3-13: Construction Informatics – Advanced Fundamentals

Intended Audience:	All master courses in civil engineering (selectable obligatory module) Obligatory module for the master courses in Computational Engineering
Duration:	2 semesters (from 5th semester up)
Lectures and Tutorials:	Scherer/Katranuschkov

Subjects: The module comprises courses on the topics ‘System Theory and Logic’ and ‘Graph Theory’. It introduces the fundamental principles of Mathematical Logic and provides an overview of the basic rules of 1st and 2nd Order Predicate Logic thereby enabling the acquisition of basic knowledge in conceptual modelling, logical reasoning and consistency checking of complex systems. The fundamentals of Relational Algebra are presented and on that basis the classification of Graphs (as e.g. simple, bipartite, multi- and hyper-graphs) together with their specific properties are explained. Furthermore, the fundamentals of graph based Network Planning are presented including topics like 'paths in networks', ‘path algebra', 'flows in networks' etc. Basic knowledge about Petri Nets is also provided to enable the students to (1) develop, (2) formally describe and (3) check in terms of consistency various functions of static and dynamic systems such as the force flows in structural systems, the transportation flow (logistics) in urban planning and construction project management and the overall information and work flows in construction projects (information logistics). The students acquire relevant system-theoretical knowledge and learn composition and representation methods that will enable them to distinguish between various formalisation possibilities such as state-space-based, event-based or activity-based modelling.

Module BIW4-22: Cooperative Design Work and Numerical Methods

Intended Audience:	Master programme in structural and computational engineering (selectable obligatory module)
Duration:	2 semesters (from 7th semester up)
Lectures and Tutorials:	Scherer/Katranuschkov/Reuter

Subject: This module comprises two courses on the topics 'Numerical Engineering Methods and Visualisation' and Methods for Collaborative Work'. The first course imparts basic knowledge about the numerical algorithms for (1) function approximation, differentiation and integration, (2) the solution of non-linear systems of equations, (3) boundary problems in ordinary differential equations of first and higher order, (4) partial differential equations and (5) eigenvalue problems, as well as knowledge about the stability and decidedness of numerical solutions. It provides also principal knowledge about the visualisation of multidimensional variables thereby generating skills to use graphical methods for the visualisation of engineering values and entities in goal-oriented manner, in order to correctly determine system behaviour. The second course imparts basic knowledge with regard to (1) distributed information management with long engineering transactions, (2) cooperative work methods, (3) workflow methods and (4) data security. On the basis of this module the mathematical and information technology prerequisites for efficient practicing of networked cooperative design work are acquired.

Module BIW4-33: Software Systems

Intended Audience:	Master programme in construction management (selectable oblig. module)
Duration:	2 semesters (from 7th semester up)
Lectures and Tutorials:	Scherer/Katranuschkov, Windisch

Subjects: The module comprises courses on the topics 'System Development' and 'System Integration'. It imparts capabilities (1) to conceptualise an integrated information system that satisfies the requirements of a construction project, and (2) to use efficiently proprietary software programmes applying as much as possible commonly known, typical tools and standardised data structures. The focus of the acquired knowledge is on practice relevant methods of system development, database design, structuring and application, and the conceptualisation of appropriate interfaces. The knowledge acquired in the area of System Development, includes the preparation and use of requirements analyses, the formalisation of the information process and the information flows, the development of system architectures and of meta data structures, and the definition of programming specifications. The knowledge acquired in the area of System Integration addresses the capabilities to develop the structure of a database using a typical database management system (DBMS), create the database itself using standard software tools, conceptualise appropriate interfaces, and integrate data converter, filter and external web-based services.

Module BIW4-69: Simulation and Monitoring of Engineering Systems

Intended Audience:	Master programme in hydraulic and environmental engineering (selectable obligatory module)
Duration:	2 semesters (from 7th semester up)
Lectures and Tutorials:	Scherer/Reuter/Faschingbauer

Subjects: This module comprises courses on the topics 'System Simulation' and 'Data and Information Analysis'. It enables the acquisition of skills for multidisciplinary conceptualisation, control and monitoring of dynamic processes in engineering systems, as well as for their modelling and simulation and the definition of appropriate interfaces for their modularisation. The students acquire the necessary knowledge about numerical and computational methods for the simulation of dynamic systems and about various approaches for the application of distributed computing. Furthermore, they acquire knowledge of the basic methods for data analysis and data reduction as well as Fourier, principal axis and wavelet analysis. The module imparts fundamental knowledge on Information and Data Mining Methods that will enable the students to correctly interpret the behaviour of an engineering system in order to identify damage and complex damage inter-relationships, system malfunctioning and system gaps, and establish appropriate risk management procedures.

Module BIW4-70: Model-Based Working

Intended Audience: Master programme in construction management (selectable oblig. module)
Duration: 2 semesters (from 7th semester up)
Lectures and Tutorials: Scherer/Katranuschkov

Subject: Through the two courses of this module the students acquire capabilities to structure and formalise complex construction projects in order to handle their information logistics and internal relationships efficiently. This enables them to design an appropriate organisational and processing structure, determine the respective information management methods and procedures and develop appropriate risk management plans. The module imparts knowledge about (1) contemporary modelling methods, (2) object-oriented data structures and the conceptualisation of meta schemas and hierarchical schemas, and (3) interoperability approaches based on methods for model mapping, matching and merging. In the first course detailed knowledge is provided with regard to methods for formal object-oriented system description, the formation of subsystems and consistency checking, and their realisation on the basis of numerical and logical algorithms. In the second course detailed knowledge is provided about the modelling of project processes and process flows, including the complementary information processes and their formal representation.

Module: Information Systems (read in English)

Intended Audience: ACCESS Master programme, European Master programme IT in construction
Duration: 2 semesters
Lectures and Tutorials: Scherer/Faschingbauer, Sharmak

Subjects: This module is comprised of three parallel courses: (1) Management Information Systems, (2) Information Mining, and (3) GIS for Infrastructure Systems.

The first course introduces the methods for object-oriented modelling of complex engineering systems. Further course material focuses on communication methods and the formal representation of communication goals which allow the efficient application of automatic evaluation and decision support methods and algorithms. A third part of the course is specifically dedicated to the use of control methods and the development of a methodology for performance measurement.

The second course introduces methods for data analysis and data mining, such as correlation and regression, classification, decision trees and clustering, whose practical application aims at the early detection of damages and faulty system behaviour. In conjunction with that the scope of application and how the methods are complemented are discussed. Part of the course is specifically dedicated to data pre-processing since the efficiency of the methods strongly depends on the modelled data.

The third course provides an introduction into graph theory, by which the partitioning and the formal area-related variables dependencies can be described. The mapping from object-oriented data models to area-related representations and the generation of area boundaries by means of data mining methods are discussed. Different ways of graphical representation for complex, multi-layered information in terms of area magnitude are introduced. The lectures and tutorials provide insight into preferred modelling and data analysis techniques for corresponding graphical representation methods.

Course: Informatics in civil engineering

Intended Audience: 6th semester, students of science of the economy
Lectures and Tutorials: Scherer/Reuter

Subjects: This lecture aims at giving an introduction to the specific problems of software in civil engineering, the special requirement to the hardware, the way of work with the software and the future trends. Especially the area of the functionality of CAD- and CAE software will be discussed. The students get a survey of the software used in civil engineering offices and can acquire knowledge that allows them to judge such software products concerning quality and performance. A further aim is to enable the students to assess the expenditures on installation of new software, training of staff to operate it and carrying out of projects by appropriate software products.

Module BIWO-04: Software Engineering

Intended Audience:	Master programme in Advanced Computational and Civil Engineering Structural Studies
Duration:	1 semester
Lectures and Tutorials:	Scherer/Reuter

Subject: This module aims at providing students with knowledge of the basics in software engineering for computational engineering, in particular complex software system design, data structures and numerical algorithms for continuous mathematics. The module is divided into two parts. The part software systems covers system capturing and system architecture, formal representation of systems, relational and object-oriented data structures, object-oriented modelling of complex engineering systems, communication and data exchange, user interfaces, and application for integrated engineering systems for monitoring and control. The part numerical methods covers the construction and analysis of algorithms to solve continuous mathematical problems, direct methods to compute the exact solution to a problem in a finite number of steps at unlimited computer precision, iterative methods to compute approximations that converge to the exact solution, solution of linear and non-linear equations, systems of equations and eigenvalue problems, numerical integration and interpolation, and implementation of the algorithms in software applications.

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[2] FASCHINGBAUER G. & SCHERER R. J. (2010). Semi-Automation of logical decisions in monitoring procedures to realize adaptive geotechnical construction methods; In: Tizani, W. (ed.) Proc. 13th International Conference on Computing in Civil and Building Engineering (ICCCBE 2010) and 17th EG-ICE Workshop, 30 June - 2 July 2010, Nottingham, UK.

[3] HILBERT F., KATRANUSCHKOV P. & SCHERER R. J. (2010). Dynamic context-aware information access in virtual organizations; In: Tizani, W. (ed.) Proc. 13th International Conference on Computing in Civil and Building Engineering (ICCCBE 2010) and 17th EG-ICE Workshop, 30 June - 2 July 2010, Nottingham, UK.

[4] SCHAPKE S.-E., KATRANUSCHKOV P. & SCHERER R. J. (2010). Ontology-based ICT platform for management, simulation and decision making in large scale construction projects; In: Tizani, W. (ed.) Proc. 13th International Conference on Computing in Civil and Building Engineering (ICCCBE 2010) and 17th EG-ICE Workshop, 30 June - 2 July 2010, Nottingham, UK.

[5] ZAHEDI K. A., SCHERER R. J. (2010). Wave Type Based Real-Time Prediction Model to Generate the Earthquake Signal; In: Proc. 14th European Conf. on Earthquake Engineering, Aug/Sept. 2010, Ohrid, Rep. of Macedonia, ISBN 978-608-65185-1-6. ID: 907.

[6] FUCHS S., KATRANUSCHKOV P. & SCHERER R. J. (2010). A framework for multi-model collaboration and visualization; In: Proc. ECPPM 2010 Conference “eWork and eBusiness in Architecture, Engineering and Construction”, 14-16 Sept. 2010, Cork, Ireland, publ. by Taylor & Francis Group, London, UK. ISBN 978-0-415-60507-6.

[7] RYBENKO K., KATRANUSCHKOV P. & SCHERER R. J. (2010). Towards ontology-based business process management in construction; In: Proc. ECPPM 2010 Conference “eWork and eBusiness in Architecture, Engineering and Construction”, 14-16 Sept. 2010, Cork, Ireland, publ. by Taylor & Francis Group, London, UK. ISBN 978-0-415-60507-6.

[8] SCHERER R. J. & KOG F. (2010). Transformation of Business Process Models into Petri Nets for Building Process Simulation; In: Proc. ECPPM 2010 Conference “eWork and eBusiness in Architecture, Engineering and Construction”, 14-16 Sept. 2010, Cork, Ireland, publ. by Taylor & Francis Group, London, UK. ISBN 978-0-415-60507-6.

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[10] SCHIRWITZ U., REUTER U. & SCHERER R. J. (2010). Application of fuzzy analysis in simulation of construction processes; In: Proc. ECPPM 2010 Conference “eWork and eBusiness in Architecture, Engineering and Construction”, 14-16 Sept. 2010, Cork, Ireland, publ. by Taylor & Francis Group, London, UK. ISBN 978-0-415-60507-6

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Positions in Editorial Boards of Journals

Advanced Engineering Informatics	Elsevier Publishers	The Netherlands
Automation in Construction	Elsevier Publishers	The Netherlands
Information Technology in Construction (electronic journal)	HANKEN School of Economics	Finland
Construction Innovation	Arnold Journals Publisher	UK

Membership in Standardization Groups

DIN NA 152-06-06 A17	Standardization committee for technical product documentation in civil engineering	Chairman
DIN NAM 96.4.1-3	Product data exchange in civil engineering	Vice chairman
ISO 10303/BC	Standard Exchange of Product Data, work group Building Construction	Member
buildingSMART / IAI	Building SMART International Alliance for Interoperability, German Council (product modelling in AEC/FM)	Co-ordinator of the academic group in Germany
IAI/ST-4	ST-4 Structural Model	Vice chairman