TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUT FÜR BAUINFORMATIK

PROF. RAIMAR J. SCHERER

JAHRESAUSBLICK

RESEARCH AND LECTURE ACTIVITIES IN 2013

December 2012

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

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

The view of the brochure is directed to the future – to the new ideas and plans for 2013 based on the results achieved in 2012. Research topics are: (1) building information modelling, (2) multi-models, (3) interoperability, (4) generic model filters, (5) intelligent construction management, (6) virtual organizations, (7) project risk management, (8) dynamic process modelling, (9) simulation, (10) e-learning and (11) energy-efficient buildings. The methods and technologies mainly applied are: object-oriented modelling, process modelling, ontologies, description logic, service-oriented architectures, grid and cloud computing, stochastics and vulnerability.

2012 was very successful in gaining research results. It was very much shaped by the Mefisto project, which was prolonged by 6 months until 30th September 2012. This brought a lot of work to the institute but also a lot of new results concerning multi-models, construction site simulation, multi-media visualization, interoperability and ontologies. The first versions of our multi-model BIM tools went online and can be reached at (*http://mefisto-bau.de/resources/resources_software.html*), namely the filter toolbox BIMFIT, the multi-model container viewer and manager M2A2. The multi-model container method was submitted to buildingSMART in November 2012 and the lean IDM method, a collaborative result of AEC3 in the CIB-EU project HESMOS was submitted in buildingSMART in October 2012. What was less successful is new research project acquisition. In January 2012, eWorkBau, the BIM e-learning project for handicraftspeople, started and one year later the EU project SE-Lab will start, where our institute and 2 industrial partners will develop a BIM- and grid-based virtual lab for structural engineering analysis. Two other proposals are still pending: one about cyber-physical elements and one about multi-model BIM use in the sub-contractor chain.

The institute strongly promotes ICT in research and industry. Prof. Scherer is chairman of the European Association of Product and Process Modelling, which held its 9th ECPPM conference in Reykjavik, Iceland from 25th-27th July 2012 (*http://www.ecppm.org*). The conference, being the oldest BIM conference, was a success with over 150 participants and over 120 papers. In conjunction with the conference, the 3rd Workshop on ee-Building Data models was held, which underpinned the importance of BIM methods for energy-efficient design and maintenance of buildings. This year the institute will organize the PRO-VE'13 to be held in Dresden from 30th September through 2nd October 2013 (http://www.pro-ve.org).

Know-how transfer to the industry has a high priority for the institute to facilitate practical exploitation of the innovative ICT solutions developed. For the industry CiB is a contact point in BIM and construction ICT. It 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 September 2012, the institute co-organized the 3rd Mefisto conference (see *http://mefisto-bau.de/congress/congress3.html*) and the 3rd conference “Bauinformatik – Baupraxis” (construction informatics – construction practice), supported by the “Dresdner Bauinformatik-Gesprächskreis” (Dresden Construction Informatics Roundtable), both held in Dresden.

E-learning activities have been extended with the project eWorkBau, which focuses on the interfaces for BIM access, the development of a domain-based BIM query language and web-based best practice BIM use cases. The European on-line master course “IT in Construction”, co-ordinated by the University of Maribor, Slovenia, is now in its 9th academic year and students can enrol at 7 European universities.

In March 2012, Ulrike Schirwitz decided to leave the institute for the industry and we lost competence that we built up in the preceding 2.5 years in the field of fuzzy methods in construction management. In October Andreas Hollmann and Ulf Wagner, in November Sven-Eric Schapke left the institute but the latter two are still enrolled as external PhD students and intend to submit their PhD works in early 2013. In October, Frank Opitz, a civil engineer has joined the institute, whereas Ksenia Roos has to postpone her comeback because of her parental leave. Altogether 5 of our researchers were or are still on parental leave for several months each, what was and is a challenging situation here and there for the institute but finally successfully managed.

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

Dresden, in December 2012 Raimar J. Scherer

Institute of Construction Informatics

		Phone extension	Email name
Head of Institute	Prof. Dr.-Ing. Raimar. J. Scherer	3 35 27	Raimar.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

Dr.-Ing. Gerald Faschingbauer	3 42 62	Gerald.Faschingbauer
Dipl.-Ing. Ronny Windisch	3 97 75	Ronny.Windisch
Dipl.-Medieninf. Alexander Wülfing	3 46 15	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
MSc 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
Dipl.-Ing. Frank Opitz	3 97 75	Frank.Opitz
MSc Hervé Pruvost	3 57 42	Herve.Pruvost
MSc Yaseen Srewil	3 97 76	Yaseen.Srewil
Dipl.-Ing. Arch. Helga Tauscher	4 25 41	Helga.Tauscher
Dr. MSc Amin Zahédi Khaméneh	3 49 57	Amin.Zahedi

PhD students extern

Dipl.-Ing. Alexander Gehre	Alexander.Gehre@semproc.de
MSc Hermin Kantardshieffa	kantards@informatik.htw-dresden.de
MSc Nazereh Nejatbakhsh	Nazereh.Nejat@opb.de
Eugenie Pflaum	eu.pflaum@googlemail.com
MSc Ksenia Roos	Ksenia.Roos
MSc Sven-Eric Schapke	Sven.Schapke
Dipl.-Ing. Ulf Wagner	Ulf.Wagner

MSc Denis Smirnov (Erasmus Mundus EMA 2 MULTIC scholarship)

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

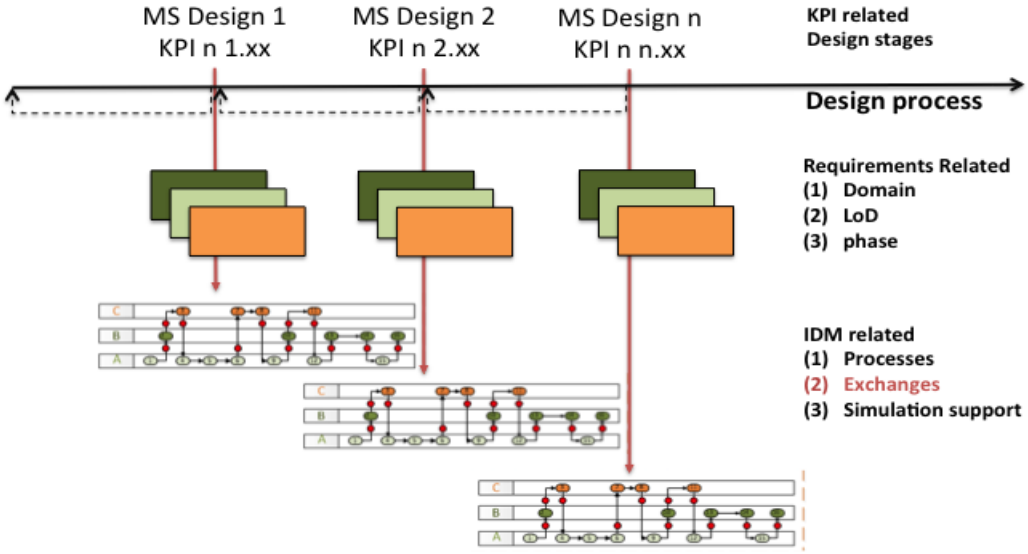
Overall the employees at the institute cover a broad range of expert domains as well as languages with researchers from Bulgaria, France, Iran, Russia, Syria and Turkey.

Requirements for an IT-supported eKPI-Based Holistic Green Building Design

Romy Guruz

Objectives

The design of green buildings is a complex process, in which several multi-domain lifecycle aspects have to be considered. It requires well-organised holistic interdisciplinary collaboration of architects, MEP designers, automation system providers, energy suppliers and energy design experts to ensure that the realisation of the energy system and the energy-efficient performance of the building as well as its optimal embedding in the energetic surroundings satisfy the specified business, environmental and societal targets. The goal of this research is to set the foundation for successful achievement of the complex energy-aware collaboration process by defining a new IT-supported holistic design management methodology based on quantified performance objectives expressed as hierarchically organised Key Performance Indicators (KPIs) taking into account and aggregating various energy-related design aspects that can be used for fast and well-grounded design team cooperation and decision making. A specific objective is thereby the proper definition of realisable requirements upon which the envisaged methodology can be built.



Requirements specification including process and information analysis

Approach

In general, KPIs are metrics enabling long-term coordinated control of the multi-disciplinary design work. They consolidate important design parameters to allow fast and reliable judgement of the achievement of the design targets in all design phases. We embrace this idea to define *energy-enhanced key performance indicators* (eKPIs) that can provide for more efficient IT-supported green building design, holistically taking into account various design aspects, many of which are ignored or underestimated in today's design work.

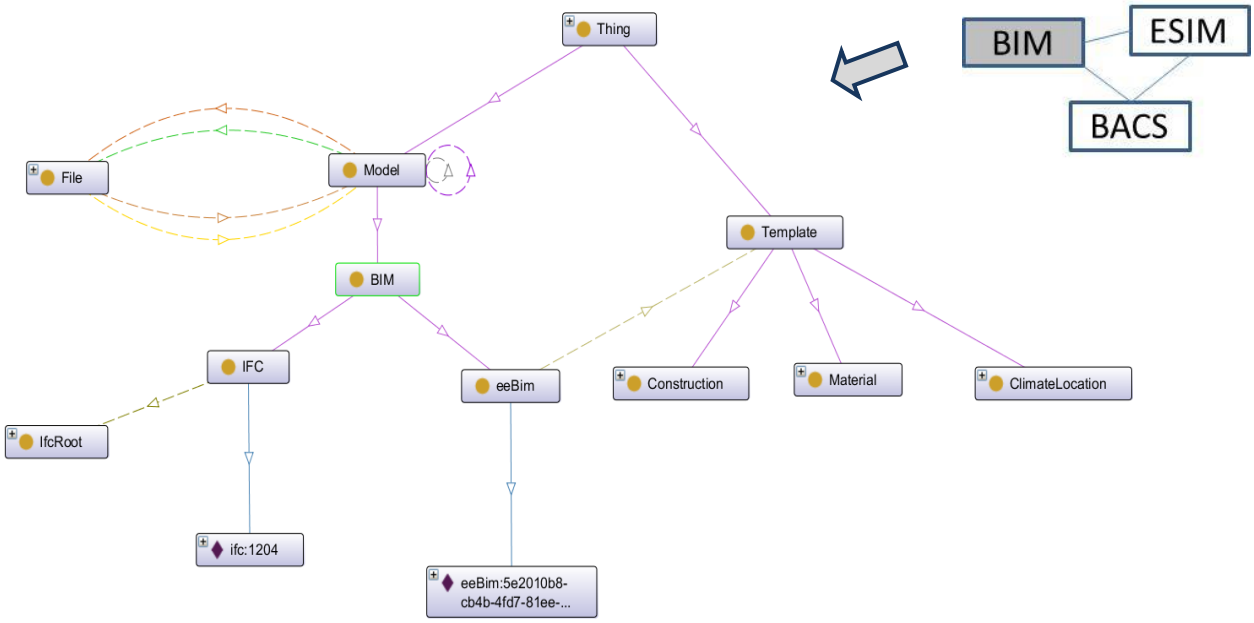
To achieve that, the requirements for the complex multi-disciplinary design process will be set up, taking into account the iterative design cycles and the related step-wise design refinements, expressing the information demand and quality at each step in general terms and explicitly showing the interaction of experts represented through their roles. Coordination points and milestones of the design process will be expressed in terms of eKPIs, hierarchically structured according to the three dimensions: (1) Domain, (2) Level of Detail and (3) Lifecycle Phase. To take the latter into account, both design "TO-BE" ePKIs and measurable "AS-IS" eKPIs will be defined to enable efficient lifecycle energy performance and control. Special attention will thereby be given to eKPIs that can be derived by computational simulation and monitoring methods and not only by static (preset) parameters. All eKPIs will be developed as much as possible on BIM-IFC basis (ISO 16739) in support of advanced BIM-driven design work. Considering the strong teamwork distribution the relevant reference processes will be defined using the IDM method (ISO 29481), further enhanced in the EU project HESMOS. The main data exchange requirements will then be identified, including IFC for the main product model exchanges. Based on these exchanges, holistic eKPIs regarding the cross-domain design issues will be set up along with the requested steps for their derivation and use in the green building design process.

Development of a Meta model for Multi-Model Integration in a Virtual Energy Laboratory

Ken Baumgärtel

Objectives

Energy simulations in the building life cycle starting from the early design phase to the retrofitting phase need the combination of several data models and respective distributed information resources. Each of these models describes a specific domain related to the building's energy performance (e.g. architectural system, energy system, climatic environment, built environment) and is normally provided through a proprietary data structure based on the IT-tools in which it is used. In a virtual energy laboratory several such tools have to be considered to enable complex computations of different energy problems such as moisture, heating, lighting, ventilation, material aging etc. Hence, beside technical application integration where interfaces have to be defined, a common basis for the integration of the domain models on higher level is needed, to enable a tool-independent model driven software architecture approach. The building information model (BIM) described via the standard IFC specification (ISO 16379) is a complex model that can be used for many aspects of a building but this model alone cannot fulfil all needs of all kinds of energy simulations. Therefore, a major objective in the development of an IT-supported virtual energy laboratory is the efficient inter-linking of the involved domain models, each covering a specific information area, to a common energy-enhanced BIM-based modelling framework (eeBIM).



Main domain models to be considered (upper right) and high-level structure of the Meta Model ontology

Approach

We develop a Meta model that will provide the basis for the required multi-model management on the virtual laboratory platform. Its purpose is twofold: (1) to accomplish the integration of the distributed information resources from the different domain models, and (2) to provide for cross-domain reasoning, enabling multi-model consistency checks, knowledge-based model filtering etc. The first of these challenging issues is realised via a set of relationship objects using IFC elements as anchor points for the links to other model domains and applying the RDF/RDFS approach as baseline for the handling of distributed data across the network. The second issue will be realised by a rule-based approach, using e.g. the JBoss business rule management system Drools. The Meta model itself is specified in OWL. Implemented domains are currently ifcOWL for the BIM data, and light-weight ontology constructs for the other domains, which will be extended in future. Supported links are: *BIM – Climate* (with linking on the level of IfcBuilding and IfcSite), *BIM – Building Automation System, BACS* (linking on the level of IfcSpace, IfcBuildingElement and IfcDistributionElement), *BIM – Material properties database* (linking on the level of IfcBuildingElement) and *BIM – Space Use*, according to DIN 277 (linking on the level of a pre-defined IfcSpace property set). Extensions towards integration with a new energy system information model (ESIM) including building and neighbourhood energy supply systems, is planned in conjunction with work in the EU project ISES.

Stochastic Simulation in Virtual Energy Laboratory Platform

Amin Zahédi Khaméneh

Objectives

Forecasting the building energy demand is a complicated task. Besides the principle models which characterize the building systems and components, detailed information about the building material, HVAC systems, and weather must be taken into consideration. Furthermore, many of the simulation input parameters are depended on discreetness, non-linearity, uncertainty or variability. An estimate of the degree of uncertainties contributed from each factor is of importance to improve the robustness of the simulation models and to help the modeller and customer to have a better understanding of building simulation results. The ISES projects aims to improve the energy efficiency of buildings by developing a Virtual Energy Laboratory that will provide taking into account the stochastic nature of the involved resources and processes.

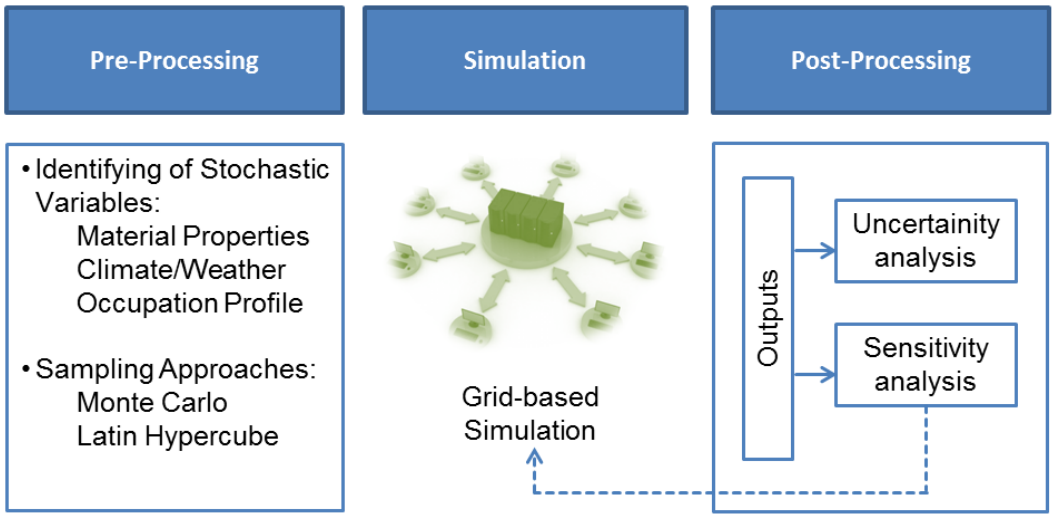


Illustration of the stochastic simulation process divided into the three phases Pre-processing, Simulation, and Post-processing

Approach

The stochastic simulation process is divided into the three phases: (1) Pre-processing, (2) Simulation and (3) Post-processing. Identification of the stochastic variables, their ranges and scope, appropriate probability distribution function (PDF) and identifying the appropriate sampling methods are conducted during the pre-processing phase. The simulation software can be integrated to run in a grid-based environment. Once the model evaluations have been performed during the post-simulation step all results from multiple simulations are collected and uncertainty and sensitivity analysis are performed.

In order to minimize the number of stochastic variables, before the uncertainty analysis the sensitivity analysis is carried out. The sensibility of the model outputs to changes in the model inputs can be measured by performing sensitivity analyses. Since the simulation itself is an expensive computing processes, finding the proper sampling approach and the optimal sample numbers are of enormous importance for the stochastic simulation. Therefore, proper defining of the input stochastic variables has an essential role in stochastic simulation. In our approach the material properties are modelled as stochastic parameters in which a random distribution forms the uncertainty in material properties, the climate and weather data are modelled using stochastic process. Occupancy profile, from which the important usage information can be derived, will be modelled as stochastic random field. The sustainability energy demand is the integral of the simulation stochastic outputs. Comparing the design indices it will be possible to find the most energy efficient scenario which is the essential aim of the virtual energy lab.

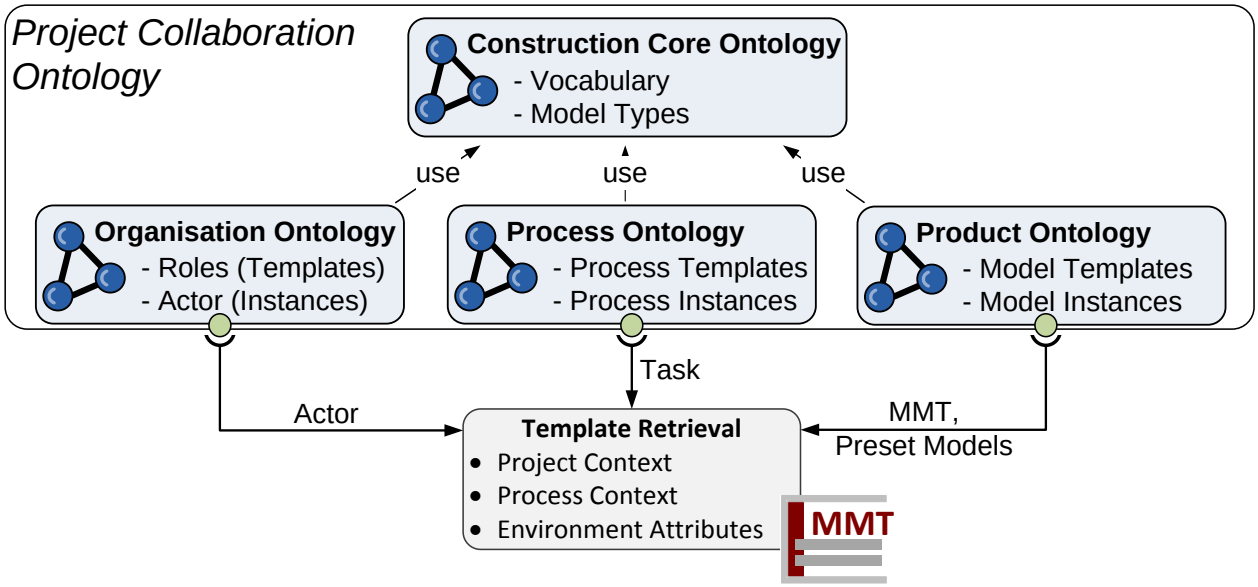
Context-Specific Multi-Model Template Management

Frank Hilbert

Objectives

In the construction industry, always separate independent organisations of different domains and disciplines joined together in various short-term forms to combine their core competencies for the handling of large and complex construction projects. The increasing complexity of construction projects and the growing requirements for specific production steps has the consequence that more and more complex and interdependent models must be exchanged between an increasing number of specialized partners. To combine different application models and their implicit dependencies in the research project Mefisto the Multi-Model-approach was developed. The corresponding multi-model container can capture the complete information about the multi-model view of a sub-process and the process information as meta-data. Therefore sub-processes can be controlled by multi-model containers. The set-up of a new sub-process can be described through a multi-model template, containing at least the process information of the sub-process.

For construction project-specific collaboration based on multi-models, project partners have to be supported with the correct selection of initial multi-model templates. Hence, the objective is to realize *context-specific Multi-Model-Template Retrieval* that considers the context of the partners, their tasks and the state of the project.



Template Retrieval using a Project Collaboration Ontology

Approach

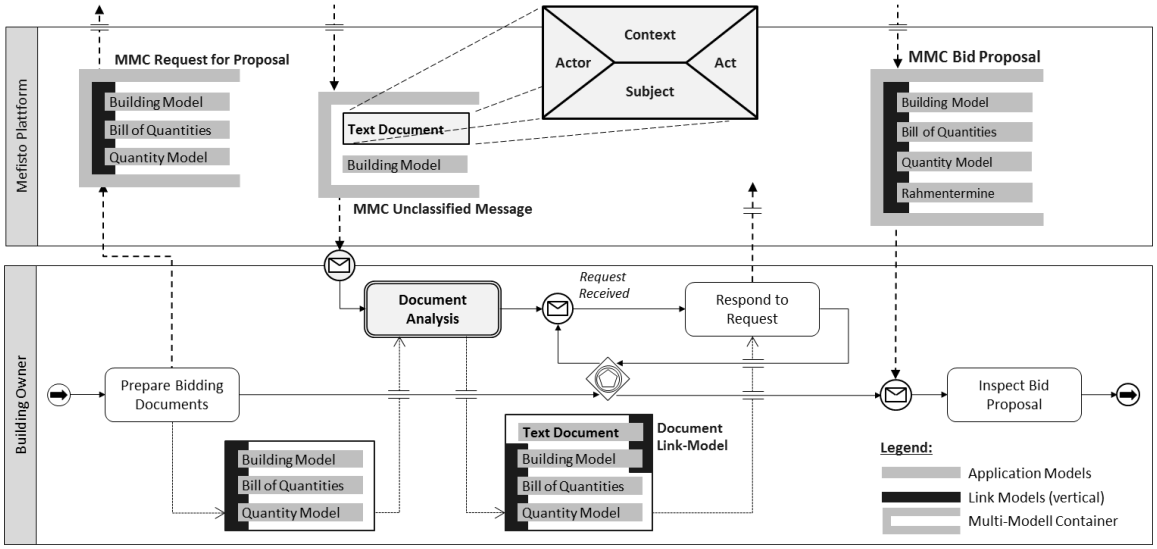
To enable the utilization of multi-model templates in a framework of integrated processes, a generic formal description of organisation, process and product information is necessary. In this approach we will use a *Project Collaboration Ontology,* which represent the entities of the collaboration organized in Organisation-, Process and Product Ontologies. The entities are described on common metadata, defined in the Construction Core Ontology. To characterize a considered situation, a context model is used, which describes the Project and Process Context based on the vocabulary defined in the Construction Core Ontology and describes implicitly the available options for an actor, instantiating processes, using existing models or create new models. The template retrieval starts by selecting suitable registered content for the described situation. Based on the detected content templates can be chosen whose characteristics allow processing in this context. Thereby templates can already contain preset models as basis for subsequent processing. If an actor accepts a suggested template, the corresponding container with possible preset models is generated. Otherwise on the basis of existing Templates and in conjunction with the entity ontologies, it is also possible to suggest and add new templates. As a result we can ensure that the involved collaboration partners retrieve a task- and situation-specific selection of multi-model templates matching the current state of all project entities (models, processes and actors).

Integrating Text Documents in Multi-Model Collaboration Processes

Sven-Eric Schapke

Objectives

With the increasing utilisation of model-based planning and controlling information there is a need to integrate heterogeneous resources of project information. In the research project Mefisto novel software technologies were developed to interlink different types of application models such as building information models, bill of quantities and project schedules and combine them in so called multi-models. The multi-model provides synchronised project information for subsequent planning, controlling and analysis applications. It can be exchanged using a neutral Multi-Model Container (MMC) format. To coordinate the creation and use of multi-models throughout a project, workflows can be applied that specify the input and output information for each task by Multi-Model Templates (MMT). The objective of this research is to extend these methods for multi-model-based collaboration to also allow for integrating text documents. For that purpose, text documents are considered a new type of application model that first of all contains unstructured project information. Using semantic annotations the content of the document and the document as a whole can be classified and interlinked with related application models.



Analyses and integration of a text document received in the process of construction bidding

Approach

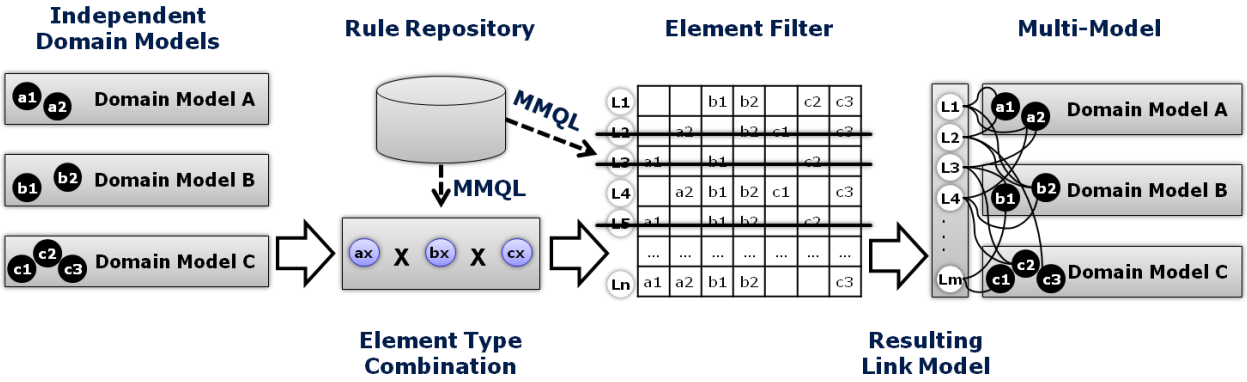
The figure above illustrates the analysis of a text document within the context of a Multi-Model Workflow for construction bidding. While predetermined formal MMCs can be used for the request and the submission of bidding information by/to the owner, intermediate requests and notifications may comprise unstructured, semi-structured as well as fully structured content as indicated by the unclassified message container. To integrate the text information from these messages with the owner's information base, text technologies can be applied to semi-automatically identify, extract and classify important text elements. In the analyses factual, contextual and intentional matters of the message have to be considered in contrast to regular engineering and management reports that often resemble to application models and comprise factual self-contained representations of the building product and its production processes. Hence, four types of message statements are distinguished that are concerned with (1) the sender (Actor) and (2) his/her intention to send the message (Act) as well as (3) the products and production processes (Subject) and the corresponding workflow tasks he/she refers to (Context). Identifying all four statements provides for interlinking the message to the respective project models representing the project organisation (Actor), the building products, specifications and processes (Subject) as well as the respective project workflow (Context) and its current status (Act). In turn, these models and their data specifications also provide the necessary vocabularies and domain knowledge to support the analyses. The figure illustrates the anticipated analysis results, triggering a request event in the bidding workflow and interlinking the text document (e.g. a request for information on certain concrete columns) with the respective building elements.

Rule based Creation of Multi-Model Links

Sebastian Fuchs

Objectives

According to the transition from building product centric to process centric way of working, cross-domain information supply gains importance, e.g. in the fields of construction management, holistic design, simulation or energy efficiency. However current domain models cannot perform this challenge on their own. Multi-modelling is a method to set up arbitrary exchangeable Building Information Models using heterogeneous domain models and explicit external links between their content elements. The approach facilitates to overcome the limit of applicability of a single model's domain schema. The task specific combination of established data models allows their optimized usage in relation to semantic practicability and user acceptance. Previous research at the institute has already enabled for independent, generic and entire retrieval of existing multi-model information spaces. However the systematic creation of links is still restricted to the utilization of some specialized proprietary software. Hence the achievable multi-model information is limited to the application domain and the implemented linking instructions of those products. Therefore a neutral method will be developed to create n-ary multi-model links between arbitrary domain models. This allows the realisation of the full potential of the multi-model life cycle for a wide range of construction information processes: the creation, exchange and retrieval of task specific information spaces, based on established data models.



Creation of Multi-Model Links using Rules expressed in MMQL

Approach

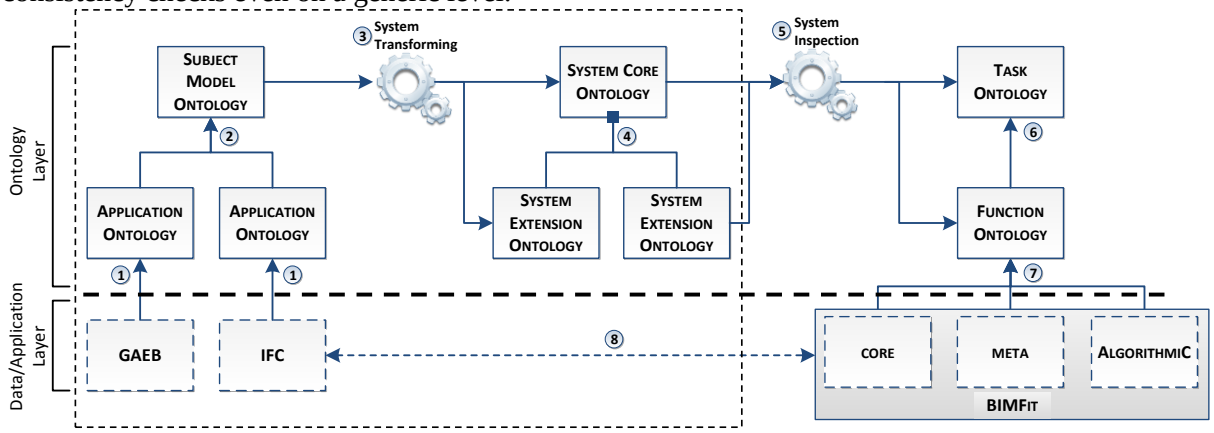
The systematic creation of multi-model links is driven by the underlying construction information process. Corresponding domain specific rules will be derived from the process, generalized and formally stored in a rule repository, e.g. in an ontology or inside a client's specialist software system. The rules describe which element types from which domain model may be linked together (Element Type Combination) as well as the individual conditions, e.g. value ranges of an element's property, which must be met to identify linkable element instances (Element Filter). E.g. the expression "`BoQ.Item.text contains BIM.Wall.material`" is a rule for linking walls and bill of quantities. The descriptions are based on a common vocabulary which is also used for metadata in multi-models to illustrate the level of detail, project phase or link type amongst others. To achieve a real creation of multi-model links, the rules must be executed in a multi-model environment which can provide generic access to the heterogeneous data models. The existing Multi-Model Query Language MMQL is already executable using the Multi-Model Assembly and Analyzing Platform (M2A2) which forms such an environment. Hence the rules will be expressed in MMQL to be applied to example data. To meet those demands, MMQL and its interpreter engine will be extended by statements for link creation. A cross product based element combination mechanism will be developed to set up an entire linking space. Existing and yet to be created element filters are then used to identify elements of interest and to eliminate unwanted combinations. As each link is potentially n-ary according to one or more of its element types, a method for grouping combinations has to be designed. Each combination group builds up one multi-model link which is added to the resulting link model. This link model plus the original domain models constitute the demanded multi-model of the particular construction information process. This research work was triggered by the Mefisto project.

Towards a core system ontology for realizing interoperability between BIM and other AEC specific models

Mathias Kadolsky, Ronny Windisch

Objectives

For various engineering software like CAD-software, ERP-software, FE analysis software and other planning, simulation or monitoring software different kind of data are required throughout the entire construction project. Thereby, the required data belongs to different project phases and describes different levels of detail of the project. Therefore, the corresponding software models provide data schemas, which enable on the one side the instancing of objects and relationships and the defining of attributes with regard to the necessary input and the results of the application, but which show on the other side a high degree of syntactic and semantic heterogeneity. Even with data models like the IFC or GAEB standard introduced to support the data exchange between different applications, for certain engineering problems focusing on specific engineering systems the defined vocabulary, the given rule sets and the existing extension methods are insufficient to connect semantically the content of the different application models relevant for the description of the entire engineering system. So, interoperability between these application models is not sufficiently available in order to carry out consistency checks even on a generic level.



Conceptual system ontology framework: model ontology (left) & system ontology (centre) – right part of the ontology framework see Windisch/Kadolsky

Approach

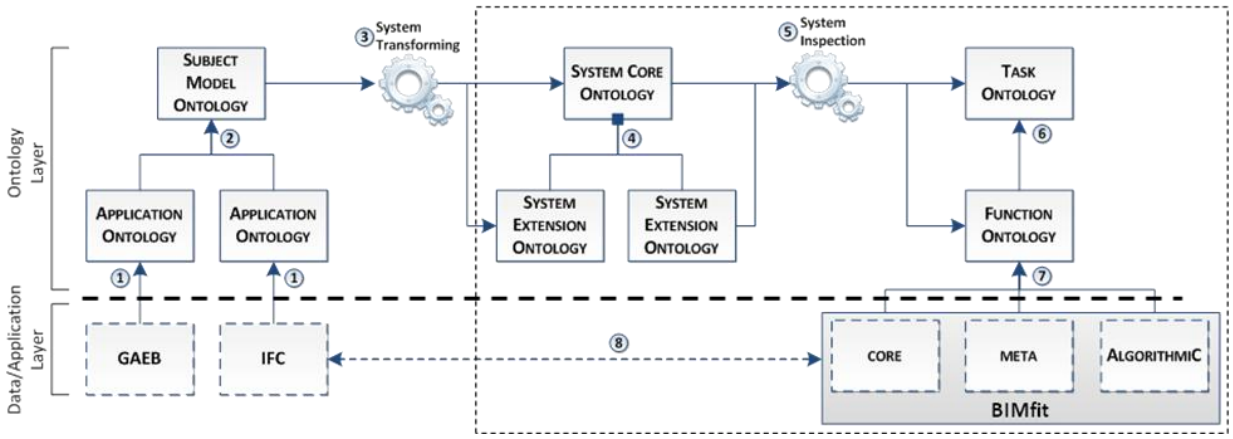
A generic ontology-based solution is proposed to integrate different application models, to extend these models with necessary system information and to enable task and function specific validation and verification tests serving as starting point for further semi-automatic methods like auto-corrections. The ontology-based approach consists of four specific ontologies. There, the application ontology (1) represents the meaning of the application models in an ontology-based form (OWL). Next to the syntactical transformation a schema filtering is also performed reducing the content with regard to the targeted engineering system and the related tasks and functions. Thereby, the focus lays on the set of information necessary for providing model consistency and not on the information set relevant for engineering simulations. (2) In most cases application models like the IFC comprise subject specific submodels like HVAC or cost models and their content overlaps with the content of other application models. To make such implicit connectivity explicit and to improve the integration process in general such submodels are identified and formulated in OWL. (3) Application models are designed for common use and contain not enough semantics to formulate system-based dependencies between objects. Therefore, relevant object model descriptions will be extracted and extended with engineering system information like specific modeling rules. (4) The resulting system ontology will be structured in a core ontology containing the building as central aspect and extension ontologies capturing detailed information like aerodynamic descriptions required for aerodynamic building systems. (5) To inspect the modeled system reasoning methods are considered offering the possibility to perform generic as well as extended tests. (8) For a more specific function related analysis an integrated inspection ontology is introduced. This ontology can also initiate operations on the original models. The elaboration of this approach is part of the research work in the ISES project.

System verification and validation using ontology-based composition and configuration of generic model filter and manipulation functions

Ronny Windisch, Mathias Kadolsky

Objectives

The structural and semantic integration of different domain models (e.g. building model, cost model) in terms of an engineering system is a prerequisite to enable a more holistic view on the building model and the various, interdependent engineering systems it integrates. In order to achieve such a holistic building model a major challenge is the existing lack of interoperability and the highly semantic heterogeneity of the different application models and information resources involved in the various application tasks (e.g. structural, aerodynamical analysis, thermal energy simulation, emergency evacuation simulation). The model integration needs to establish a semantically unified data model enabling an explicit formal representation of the structural, abstract, physical and geometrical relationships between elements defined in different application models that constitute an engineering system. Ontologies are widely seen as a promising technology to achieve such kind of interoperability. However, using ontologies for the representation of engineering systems the question remains how can they be validated and verified in terms of qualitative and quantitative model criterions with respect to the system context, applications tasks and the related applications models. The required querying and manipulation functionality goes beyond the capabilities of traditional ontology-based querying approaches like SPARQL since they may involve advanced algorithmic and transformation operations that have to be performed on the application models as well.



Conceptual system ontology framework: core and extension system ontology (centre) and inspection ontology (right) – left part of the ontology framework see Kadolsky/Windisch

Approach

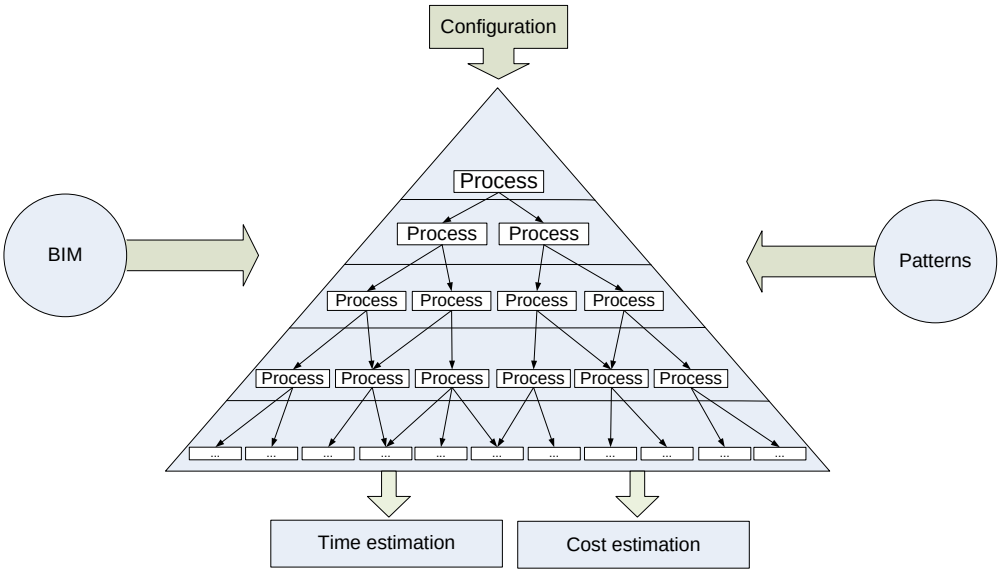
The approach is to provide the needed model filter and manipulation functionality through the application of the recently developed generic model filter and manipulation framework BIMfit. BIMfit offers various functionality for model filtering and manipulation based on a layered set of meta (data level), core (semantic level) and algorithmic functions. This basic set of functions allows for the composition of complex filter and manipulation operations on domain and application level. Thereby each function is applicable to various filter or manipulation tasks. The application of a certain function within a composite operation is determined by its configuration. The function configuration is defined by its range and type of input and output values, the type of objects it is applicable to and the possible representations of the semantical concepts to be processed. The set of functions can be described semantically in terms of a functional model that will be represented in a function ontology (7). This function ontology describes the relationships between the single functions and their possible combinations to composite operations with respect to a certain application task. Since the application tasks are depending on the system context and the involved application models they require different functional compositions as well. Therefore it is necessary to separate the functional model and the tasks by establishing a separate task ontology (6). The relationship between the task and the function ontology allows for the envisaged automatic context sensitive configuration and composition of the asked filter and manipulation operation. This research work is part of the EU projects ISES and SARA.

Intelligent process configuration with preliminary time and costs estimation on different level of details

Alexander Benevolenskiy

Objectives

In the last years the need to automate and optimize construction processes has become more and more important as an efficient baseline for BIM supported working. Most of existing approaches for the generation and optimization of construction schedules consider only geometrical aspects of the configuration by using Building Information Model (BIM) as an input. However cost and time estimating are one of the most important steps in construction project management and therefore they also should be taken into account. Furthermore preliminary estimation of time and cost already on the early configuration steps can not only provide necessary information for planning of construction process, but also have a significant influence on the configuration process itself. The objective of this work is to integrate the initial estimating methods into the configuration process on different levels of details, which allows getting a rough estimation of the required time and costs already on the early stages without performing a process simulation.



Process configuration with preliminary cost and time estimation on different level of details

Approach

Previous works performed in the frames of the research project Mefisto have shown the efficiency of using the generic reusable process patterns for the process configuration. In this work the estimation process will be closely coupled with the configuration process. For that purpose the existing structure of process patterns will be extended with additional cost and time parameters that are used in the calculation later. The use of ontology for the modelling of construction process patterns allows modifying these patterns easily by adding new concepts and relations. Moreover the hierarchical structure of the process model provides not only possibilities for the top-down process configuration, but also a good basis for the calculation process. The idea to associate configuration and estimation processes comes from their nature. For the both processes it is necessary to break down the initial process in a number of tasks, therefore the approach starts from the whole building and then details the processes until reaching the elements level.

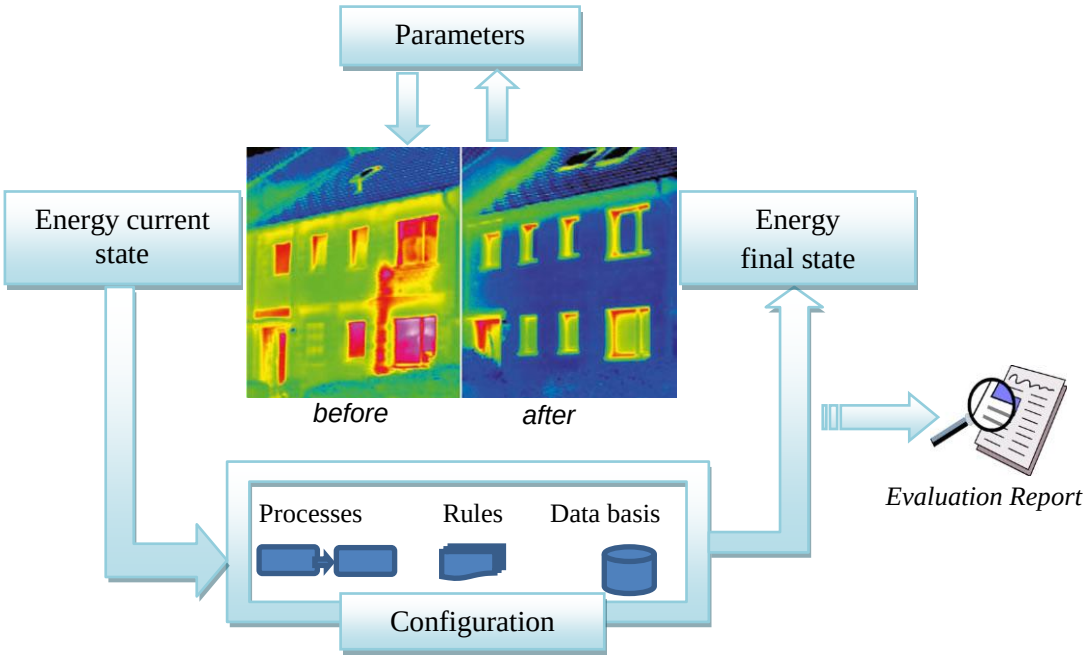
In the first step the required information comes from BIM in order to build the general process model. After that the configuration of the general process model with the process patterns is performed, that includes a semi-automatically association of the process patterns with corresponding tasks. On the last step the processes on the different levels of details are being configured depending on the evaluation of the building topology and actual resources availability. In parallel to the configuration preliminary time and cost estimations are being performed, what allows to obtain not only different configuration variants, but also get their duration and cost values.

Construction retrofit process configuration using energy data extension for IFC

Ksenia Roos, Alexander Benevolenskiy

Objectives

The legislature in Europe prescribes today more extensive energy saving measures, forcing more energy-efficient construction and renovation. Nowadays on the market there exist many energy consultants with different software helping to define and calculate the current energy state, the costs and procedures for the renovation, the energy state after renovation and its economic efficiency. This evaluation is carried out only to a small percent automatically and therefore is very time-consuming. Using IFC data model with energy extension it is possible to reach a higher grad of automation and therefore more effective planning of construction and renovation processes.



Construction retrofit process configuration using energy data extension for IFC

Approach

On the first step the IFC data model will be used for energy consumption measurements. According to the results obtained, weak spots of the building will be defined, like shell and thermal bridges. These results will be saved in the data basis. On the next step approximate processes will be created, with the activities, related to the necessary renovation procedures. For this purpose the rule engine will be used, which helps to search for the best solution within the data basis by using restrictive parameters. These parameters reflect, for example, the time-, cost constraints or explicit desired effects of the building owner. From approximate processes the highly-detailed processes will be created on the next hierarchy level. On the highest level the existing process patterns will be used, and on the lowest level the specifically instantiated processes will be created. Finally the evaluation report can be created, so that the user can decide about the economic efficiency. Varying the restrictive parameters new solutions can be compared within the minimal time. As evaluation of the suggested method the real building will be taken into account, and the planning renovation data will be compared to the real data after renovation.

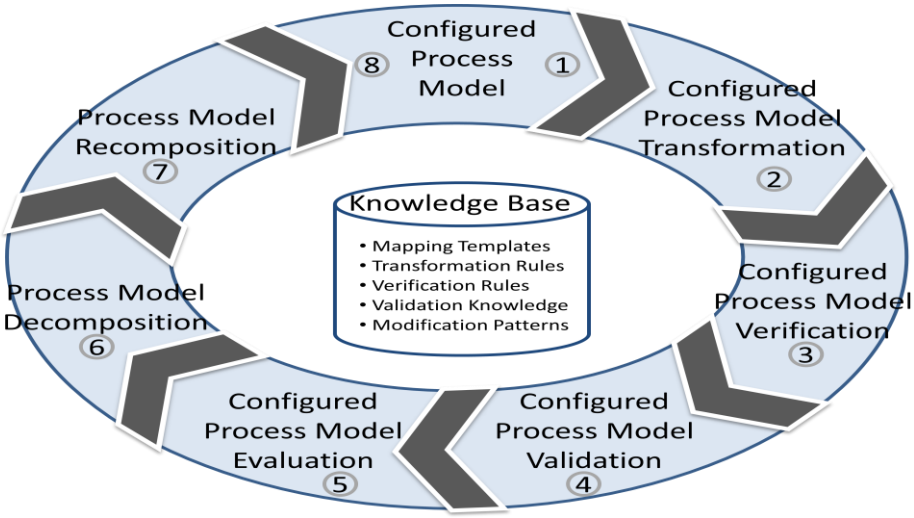
The standards EnEv 2012, DIN V 4108-6, DIN V 4701-10 are the basis for the calculation. The overall technical concept can be built upon the Process Configurator, implemented within the MEFISTO-Project.

Petri Net based Validation and Reengineering of BPMN Represented Configured Construction Processes

Faikcan Koğ

Objectives

Business Process Configuration (BPC), which is a method to integrate several business process variants into a single model, helps to omit unnecessary process parts and represents a family of process models. It provides flexible solutions to the modeled business process. Business Process Modeling Notation (BPMN), which is a technique for modeling and analyzing business processes, has underlying capabilities such as simulation that helps business managers and analysts to understand the complex processes and to quantify the system's performance. Both method and technique are used to support a nonredundant, flexible, integrable and adjustable visual environment for the business processes. Verification of the completeness and consistency system network and validation of the intended purposes of the configured process models are important problems of this environment. The same situation holds also for the construction processes, which consist of very complex and detailed processes and are not easy to model or to integrate with each other. Moreover, process modeling tools must support the process configuration with verification and validation knowledge, which supports the end users to identify and to avoid system errors like deadlocks, and determines the model coherence according to the real world. The objectives of this research are (1) structuring the verification and validation rules with knowledge acquisition to improve the configured construction processes and (2) modifying existing tools with verification and validation purpose.



Knowledge based Reengineering Lifecycle of Configured Process Models

Approach

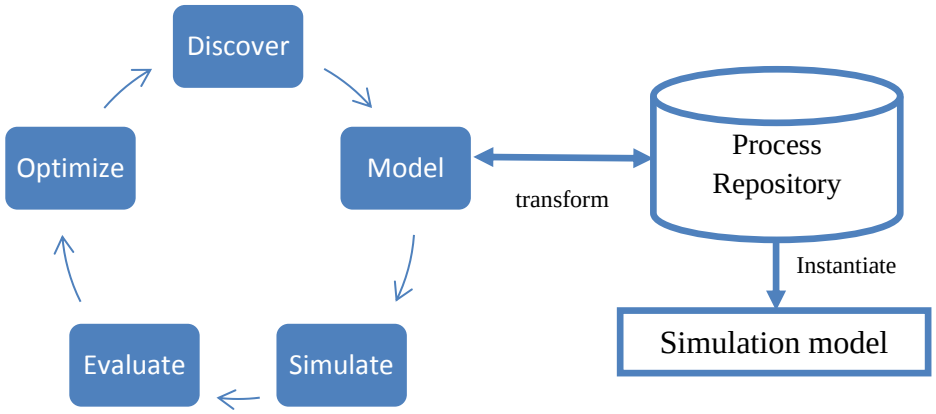
The main focus of this research is structuring a knowledge base, which includes mapping templates, transformation and verification rules, validation knowledge and modification patterns for the business process reengineering cycle. Petri Nets (PN), which is a mathematical and computational modeling language, is the selected method for the verification and validation 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. Phase 1 indicates the configured process model, which is represented in BPMN. Phase 2 is the implementation level of transformation rules and mapping templates to the configured process model. BPMN model will be transformed into the PN model, which is represented in PNML. PNML will be used in existing and modified PN tools to verify the properties (phase 3) and to validate the structure (phase 4) of the model. Phase 5, which is the evaluation phase, indicates the consequence level for the checked process model. If a model has failed in the verification or validation phases it is handed over to the reconfiguration phases, which are Decomposition (6) and Recomposition (7) phases. Process patterns, which are common or general solution for the complexity, are adapted for the integration and simplification of the knowledge base as modification patterns for verification, validation and reconfiguration phases. Finally, phase 8 indicates the storage of the reconfigured process model in the knowledge repository. According to the requirements and alterations of the system these phases can be repeated many times for further changes. Hence we illustrate this reengineering process as a cycle.

Adopting advanced process patterns for efficient process-based simulation of construction projects

Ali Ismail

Objectives

The Construction Simulation Toolkit (CST) is a process-based simulation framework, which aims to enable the rapid and realistic deployment of simulation models to support the planning of construction projects. It based on the discrete-event simulation method to imitate the behaviour of complex real-world systems like construction projects over time. The separation between the process modelling domain and the simulation engine in CST makes it possible to apply it for different kind of projects with less effort. An important criteria to indicate and improve the capabilities of modelling and thereby to simulate complex processes is to identify the standard workflow control and resource-use patterns [(1)] which can be used inside the simulation model. The current implantation of CST already supports the mapping of all basic workflow control patterns, namely: sequence, parallel split, synchronization, data-based exclusive choice, and simple merge directly from BPMN process models in form of ready to use simulation templates .However, a further investigation is needed to identify and support more advanced patterns for a realistic and efficient modelling and simulation of complex and dynamic construction operations. The objective of this on-going research at this stage is to analyse and capture a set of reusable distinct modelling constructs for construction processes and describe their operational characteristics formally. These constructs will be used to provide more intelligence and modelling alternatives, which leads as result to improve the quality of the process models as well as the reliability of simulation results.



Life-cycle of modelling new process patterns

Approach

Process models based on the Business Process Model and Notation (BPMN) are used to describe the logic and the required resources to carry out construction operations graphically and semantically. In order to support advanced workflow control patterns the basic template of atomic and compounded processes will be extended to support additional functionality. The well known "discover, model, evaluate, and optimize " method will be applied on real construction operation in order to identify and classify the required patterns. Examples of new patterns which will be target are:(1) cancel task, (2) recursion and (3) milestone. Beside the simple and direct allocation of resources new algorithms will be developed to support the following resource patterns: (1) role-based distribution, (2) case handling and (3) capability-based distribution. The implementation of basis simulation templates will be extended when possible or new ones will be created to support these advanced patters. The new process patterns are saved inside process repositories and can be retrieved, adapted and reused within the simulation model. Adopting such advanced patterns is critical especially for simulation models with high level of details during the construction phase.

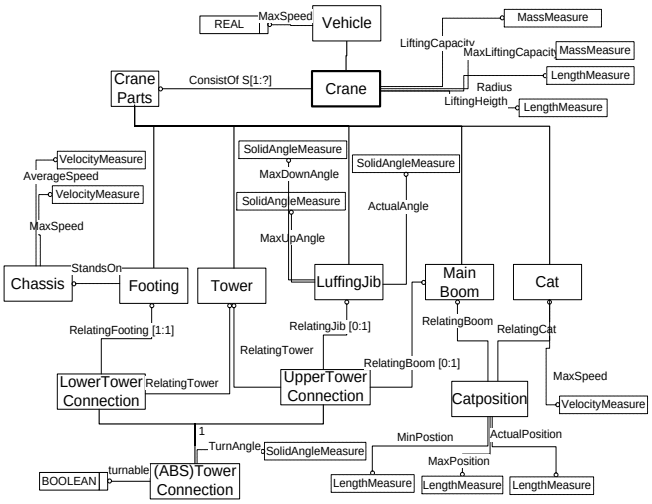
(1) Workflow patterns: http://www.workflowpatterns.com/

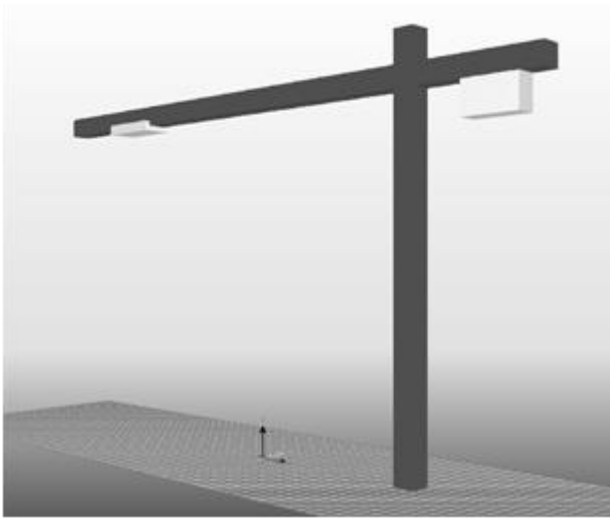
4D Construction Site Viewer Based on a Hierarchical IFC conform Model

Ulf Wagner

Objectives

To enable integrated IT-supported planning and realization of construction projects, it is necessary to design construction sites at the computer and exchange the resulting information models in digital way. Today, there are several software tools available for construction site modelling. However, often they do not integrate well with common 3D CAD programs and they do not provide for a qualified data exchange with other tools. Most often the existing construction site modellers support the visualization of the construction site equipment but they offer little functionalities to simulate the construction site processes and to prove the practicability of the planned processes, e.g. checking possible collisions of cranes, supply chain bottlenecks, storage area availability etc. The objective of this research is to develop a 4D construction site viewer that allows for the visualization of predefined animation paths as well as interactive animations. The animation paths will be preferential for workflow and production simulation proofing. With the help of user-interactive animations collision checks can be done. The viewer shall be available to normal end-users without special simulation training.





IFC-based Construction Site Model *Context sensitive Visualization*

Construction Site Equipment Model Viewer

Approach

The IFC model is a common data standard that is supported by most CAD programs for the exchange and sharing of building models. In our research the IFC schema is extended to also represent construction site elements such as construction equipment and materials. Moreover, site infrastructure elements such as roads, gateways, utilities and pipes are considered. Overall, the IFC construction site model is kept as simple as possible, complementing available IFC geometrical representations with only a few essential classes and attributes. To support more complex planning tasks such as animations, simulations and collision checks an additional library of detailed equipment models is developed. Within that library the IFC model data are complemented with more detailed geometrical information, kinematic and performance descriptions as well as respective cost data. The realization of the 4D construction site viewer is based on three essentials aspects:

(1) The description of construction site models in correspondence to the IFC standard, so that the construction site elements can be visualized and utilized within different viewers and CAD programs;

(2) The description of the animation paths separately from the IFC construction site model (thus, the construction site models remain static models that only hold the positions of construction site elements at a certain point in time while their movements are captured within external XML-based time diagrams or tables);

(3) 4D IFC viewer with an integrated animation component developed on the basis of the available open source viewer provided by the Open IFC Tools.

This research work is part of the German *mefisto* project.

A visualization mapping framework to recouple information and presentation of exchanged building information models

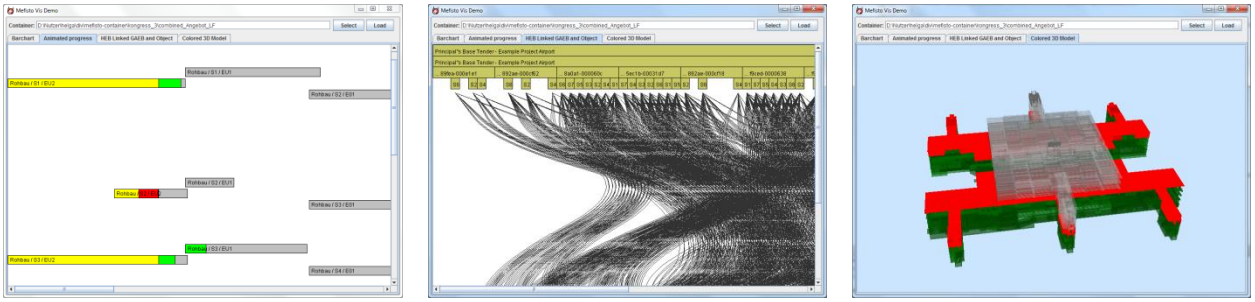
Helga Tauscher

Objectives

Research and development of a configurable nD-viewer tackles a higher goal: to recouple information and presentation, which have drifted apart naturally while building information modeling emerged and advanced. Standardized visualization descriptions, which can be exchanged together with the information model, along with flexible viewers allowing the reproduction of visual presentations based on these descriptions could bridge the accrued gap.

A specified visualization should be usable in different runtime environments, making it possible to reproduce the same visualization in different viewers capable of interpreting the specification. The need to exchange information model and final presentation (e.g. plans) in an unconnected manner would then vanish. The visualization specification should cover the whole range of possible visual presentations, whose heterogeneity is illustrated by the use case example shown below.

The figures show different visualization configurations for progress monitoring in construction management. The configurations are applied to the same information (object model, construction specification, bill of quantities, schedule, and progress reports) and use a common color scheme (yellow: finished in time, red: overdue, green: finished ahead of schedule, grey: future work) in all presentations.



Visualization configurations for progress monitoring: Coloured Gantt chart (left), quantities as coloured hierarchical edge bundles (center), coloured 4D model (right)

Approach

The visualization framework developed in the course of the Mefisto project does already fulfill part of the objectives. Due to its modular nature several data access modules such as the multi model module can be plugged in on the one hand as well as existing visualization libraries on the other hand. This results in a generic framework, which can be adapted to meet the requirements raising from the information model specifics and from the runtime environment, where the viewer component is supposed to be embedded. By abstracting away data access and rendering issues, the framework allows for the focus on the central mapping step during the development of visualization configurations.

To meet the objectives of runtime environment independence and completeness, the framework will advance further in the following directions:

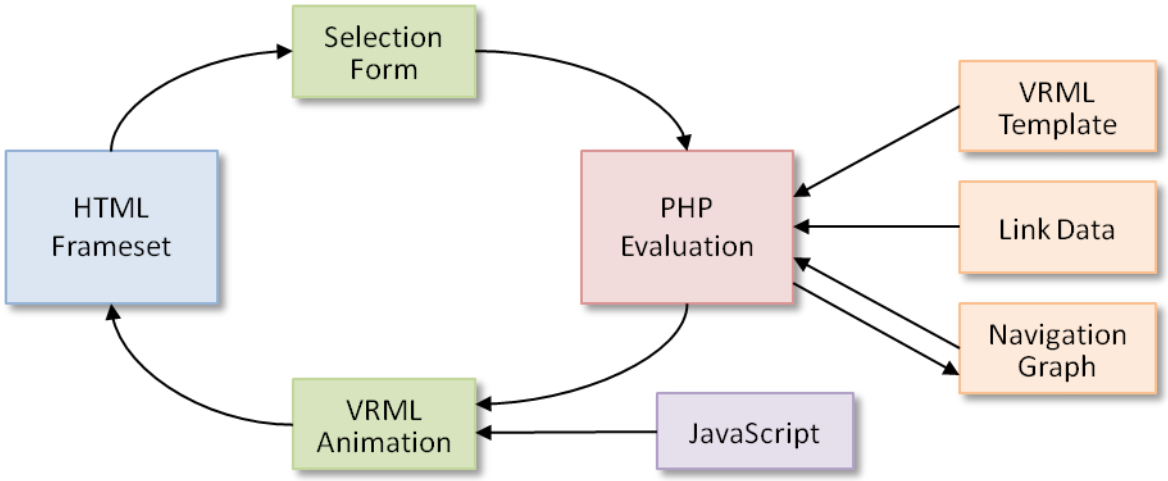
1) More complex configurations will be supported, with manifold combinations of mappings to space, time and interactivity. The definition of groups and hierarchic nesting in all dimensions will be added to the existing basic mapping rules.
2) The visualization specification will be expressed with a more compact notation. The current Java-based visualization configuration interface will be accompanied by an appropriate domain specific language accessible to domain experts. Existing query languages will be integrated for the selector specification.
3) Platform independence will be broadened beyond Java-based runtime environments. An additional prototype implementation in Javascript will feature viewer components for browser based applications. Visualization specifications written with the help of the DSL can be used with both implementations.

Navigation in Interactive Virtual 3D Building Infrastructures

Hermin Kantardshieffa, Wolfgang Oertel[1]

Objectives

Virtual 3D worlds in the form of VRML building models enable, apart from the simple viewing of three-dimensional building structures, also the interactive traversing and exploring of the models. User friendly navigation with focus on velocity and efficiency plays a substantial role in order to achieve a set of service goals. A virtual navigation is regarded, similar to the reality, as the covering of certain distances by mobile changes of the position of the virtual observer. Online applications enable an efficient implementation of target-orientated navigations in a virtual world based on a data communication between VRML and different web technologies such as HTML, PHP, and JavaScript. Thus, considerable advantages for the users result regarding to the fast attaining of spatial targets and to the easy and clear handling of the web interface. Such kinds of applications are performed in a suitable web browser via the internet where they are divided into two visual interface areas comprising the various control functions and the three-dimensional world, respectively. The goal of the proposed navigational method within the scope of a research project V3CIM[2] is to attain, as quick as possible, a desired end point from a selected start point in the virtual building whereby the resulting route is displayed by a dynamic animation or a static graph directly in the VRML scene.



Workflow of the navigation via data communication

Approach

The starting point of the web application is an HTML-based frameset. Using a predefined selection form in the area of control functions on the frameset, the start and end points of the navigation path in the building are selected. These data are forwarded to a server-side PHP script in order to accomplish the processing of the sent data. The evaluation process is based on three subcomponents: a VRML template file containing predefined way points of any floor, generic link data connecting neighboured points by linear segments, and a description of the concrete navigation graph. The last component is a non-directional graph consisting of nodes (points), edges (connections between the points), and edge intensities (distances between the points) calculated from the spatial intervals of point coordinates. The program-technical implementation of the graph search algorithm for the computation of the optimal way is done in the server-side PHP program. The result of the PHP evaluation is used together with the JavaScript functionality for the client-side control of the dynamic VRML animation. Thereby, the position and viewing direction of the virtual user are animated according to the navigation path and displayed visually in the web browser. Thus, a data communication via a web interface between the VRML worlds on the one hand and different HTML control elements, such as selection lists, links, and menus, on the other hand is effectually achieved. Alternatively, the navigation path can be visualised as a static graph on a global level. Interesting extensions of the implemented approach arising from the comprehension of spatiotemporal restrictions and obstacles as well as requirements and constraints connected with the usage of the rooms by persons and events. Application examples are optimal round tours or escape plans.

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

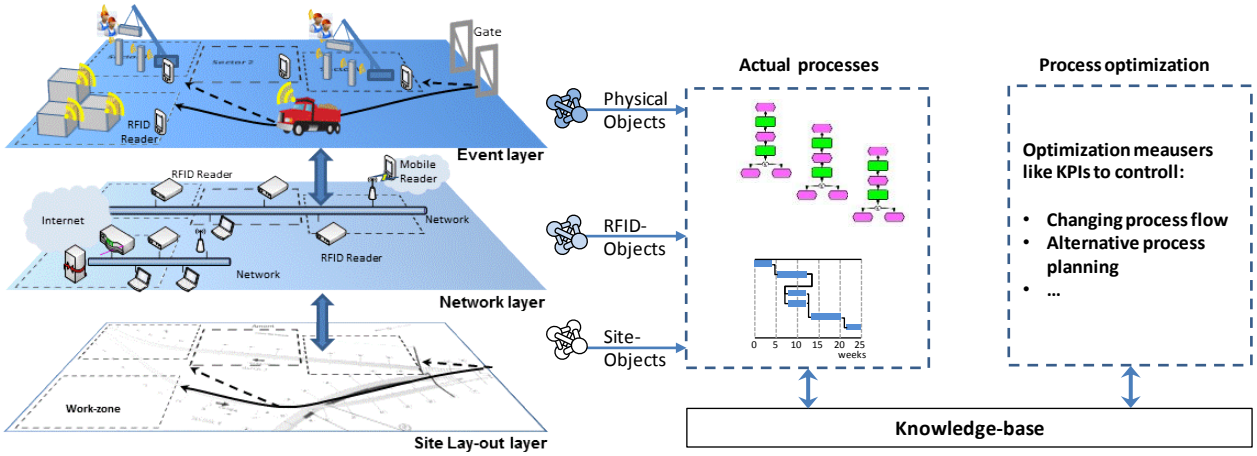
Enhancement of construction processes planning using a cyber-physical approach

Yaseen Srewil

Objectives

The efficient process planning in construction project is confronted with insufficient information about the current processes and necessary changes in the process flow realized in project execution. Many current field practices still rely on manual process for construction asset tracking and information handling. The result is that the information of actual construction processes is incomplete, error-prone and not available on time. The objective here is to bridge this information gap by using Automatic Data Capturing (ADC) technologies like RFID. These technologies enable a real-time monitoring for the entire process's progress, exceptions in execution and can support an efficient process alternative planning.

The proposed technology provides a continuous capturing of construction site data (ongoing activity, resources status, etc.). The analysis of this collected raw data performs consolidation of information, derivation of process states, updating of planned process and detecting delays in project execution. Finally, the implementation of a specific optimization measures like key performance indicators (KPIs) will be discussed to control construction process optimization.



The concept system for embedded RFID technology in identification and optimization of construction processes

Approach

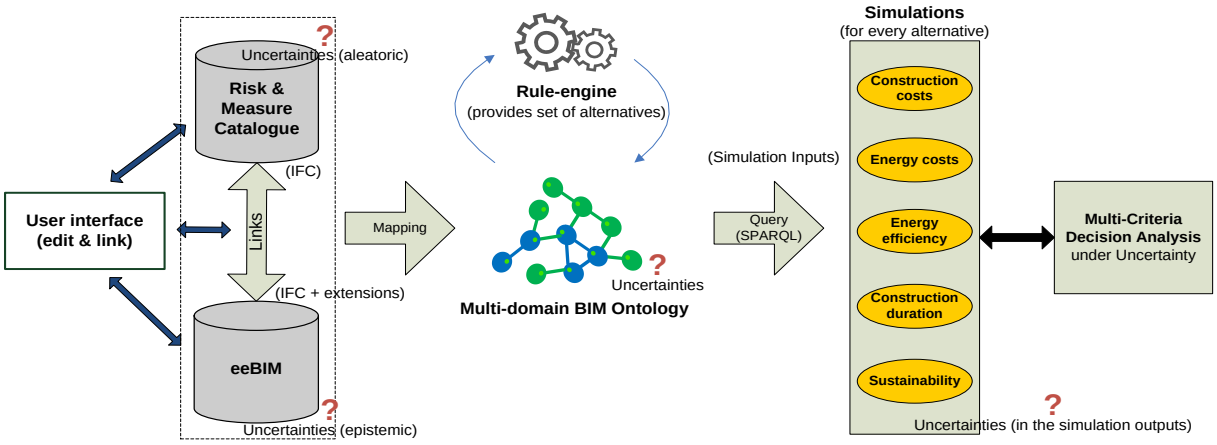
A holistic solution to integrate Radio Frequency Identification (RFID) streaming data collected from a job-site into a knowledge base for real-time monitoring of all relevant building components and resources throughout all construction phases is needed. The starting point for the solution would be coupling the real and virtual world to produce an environment where the physical and digital object interact in real-time. This provides reliable information on time to all involved actors to control activities, handle exceptions and adjust their plans. This approach considers three characteristic layers of job site: (1) Event layer representing where the construction processes take place, (2) Network layer for the mapping of events from the event layer to network configurations to make them tractable and (3) construction site layout layer; it links the network devices to their corresponding physical locations. Three mapped object types recognize: the physical objects represent the construction elements that read by RFID reader, RFID objects when the readers change their places and site objects determine the reader position and related work-zone. The collected data include the tag-id of the physical object, reader-id, timestamp and position of scanned physical object and reader. This information is driven in a knowledge-base in order to monitor the entire process progress, identify and assess potential exceptions in execution. Furthermore, the changing of process flow and alternative process planning can be controlled by using optimization measures like KPI's and configuration process templates. The proposed approach makes the construction process flexible and capable to deal with frequently changes in execution conditions. Moreover, it keeps the entire processes up-to-date. This research work is a part of the Trans-IND project.

BIM-based holistic risk management

Hervé Pruvost

Objectives

Unexpected issues are quite common in all phases of a construction project and are most of time ignored until they occur. To close this gap the international standard ISO 31000 formalized concepts and methodologies for the industries to manage their risks. The last revision of the standard defines risk as the 'effect of uncertainty on objectives' (ISO Guide 73). In this definition, uncertainties include probabilistic events and variations (aleatoric uncertainty) as well as uncertainties caused by ambiguity or a lack of information (epistemic uncertainty). It also includes both negative and positive impacts on objectives. Nevertheless companies mainly focus on specific risk categories like costs and security in a specific domain or project phase. Moreover many analysis tools came on the market focusing on quantitative simulations for cost and time analysis. But the trio cost, time, quality has been supplemented with new key objectives like energy efficiency and sustainability promoted by actual international guidelines, and this with consideration of the whole building life cycle. Thus many domains and criteria have to be taken into account when performing risk assessment and risk treatment. As central data model of the construction industry BIM can contribute to the implementation of such procedures. Moreover, more than describing the only geometrical properties of a building BIM is constantly in the process of extending its information area to other domains like construction management and energy.



Steps of a BIM-based holistic risk management

Approach

The objective of this approach is to support decision making in design and planning of construction projects with regards to the inherent uncertainties. Risk and measure catalogues can be used as libraries, the first providing for troubles experienced in past projects and the second for good practice treatment measures. On the basis of this information an ontology can be built that along with storing the data defines generic concepts about possible problems with categorization and decomposition of causes and effects, as well as relations between different types of risk reduction measures and the identified risks. Ontology gives among others the advantage to handle incomplete information i.e. uncertainties resulting from a lack of information. The BIM standard IFC already offers good foundations to model risks and their impact as well as associated measures. Existing tools e.g. IfcOWL allows for mapping IFC-based catalogues and relevant BIM views into ontology. On this basis and with the help of rules several good practice design and planning alternatives can be qualitatively provided to reduce risk. These have then to be ranked in regard to the decision criteria mentioned above and to the uncertainties remaining in the model. Indeed, the choice of a specific energy system regarding possible future normative constraints could be not robust enough in case of varying space planning or a new construction task could use a resource with uncertain cost. For this purpose a Multi-Criteria Decision Analysis under uncertainty can be performed (e.g. stochastic or fuzzy MCDA). Repeating this cycle enables an incremental optimization in detailing the model all along the project and from the early project stages.

The future place of the craftsmen in the BIM process chain

Alexander Wülfing

Objectives

Until now the affairs of craftsmen from small and medium-sized companies is affected by the use of multiple proprietary craft specific software, e.g. for accounting, planning and paperwork (sketches, parts lists, etc.). This makes the coordination with other crafts the design offices and construction companies difficult. BIM (Building Information Modeling) based work helps to enhance these coordination problems due to the use of standardized BIM models over the whole life-cycle of the building (design, facility management, etc.). Furthermore there are more advantages for craftsmen which could be useful in the craftsmen affairs. For example it is possible to derive an inventory list from the BIM model if the data administration of the model is done properly through the life-cycle. In case of the execution phase the craftsmen should use reasonably priced mobile devices for the information input into the BIM model. The objective is to incorporate the craftsman to get or deliver the needed information, i.e. information extraction (filtering) is a vital task which must managed over the whole life-cycle of the building. The role/place of the craftsmen in this process depends on the project size and contains a specialized planning and/or execution as well as the information input (see Fig. 1).

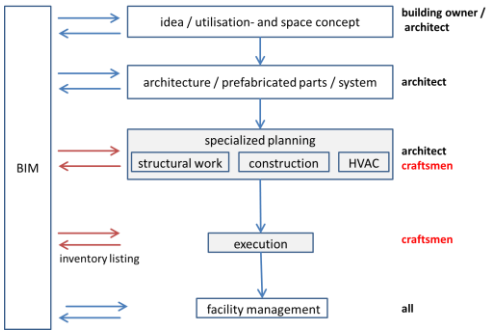


Fig. 1: Use of BIM over the whole life-cycle of the building.

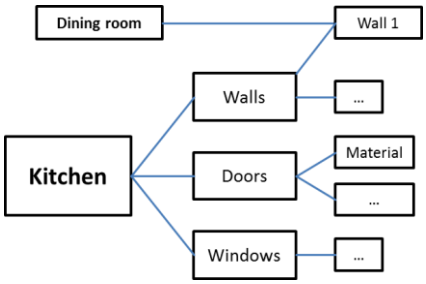


Fig. 2: Possible User Interface for craft specific filtering.

Approach

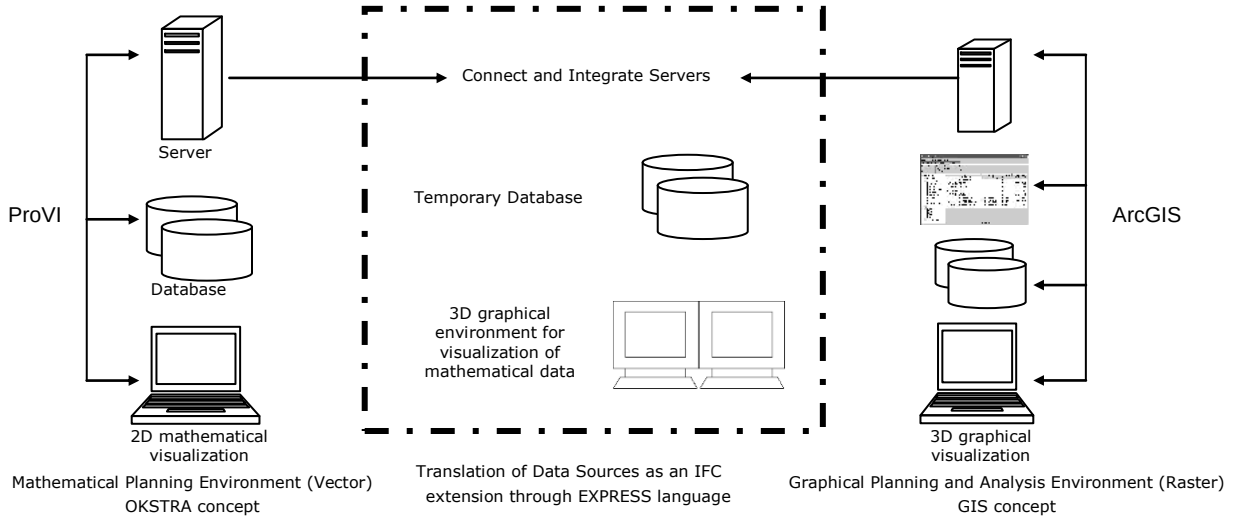
Based on a (multi-model) filter toolbox a handicraft specific BIM access toolkit will be developed which provides inspection and filtering of the BIM model and conversion of the information for craft specific tools preferable in a data format which can be accessed easily by the craft tools and craftsmen (e.g. XLS format). The use of the multi model approach allows the use and connection of different domain specific models (e.g. structural work model and bill of quantities). In a first step trade specific information will be developed and analyzed dependent on the phase in the life-cycle (planning, execution, etc.) of the building together with the craftsmen. In the next step it must be examined if and how this information is available in the BIM model(s) as well as in the craft specific tools. In the latter case it should be regarded if information can be mapped to or derived from concepts which are contained in the BIM model(s). The goal is to cover as many as possible information needs with the filter functions. The filter toolbox respectively the craft specific filter functions for the extraction of the information needs must be easy to use for craftsmen. From a psychological point of view relations between objects of a BIM model should be visualized. This must be done in a flexible way like a graph (“mind map”) which can be detailed based on the relation depth which considers the craft specific view of certain elements (e.g. all elements which relates to the kitchen, see Fig. 2) and not only a view which is realized through the often used tree structure. In such a tree view a building is subdivided into storeys and building elements are assigned to the appropriate storey. Because such a structure could not visualize relations between objects if these objects belongs to other objects outside the tree structure (e.g. if a wall belongs to space 1 and space 2) an easy to use graphical user interface for craftsmen specific filtering based on such a mind map concept will be developed in cooperation with the Chair of Learning and Instruction.

Towards the Interoperability of Traffic Infrastructure Planning Tools and Geo-Information Systems

Nazereh Nejatbakhsh-Esfahani[1]

Objectives

With the increased complexity of today's projects and the dynamic nature of the construction sites, and the fact that most of the sites are remote from the planning and engineering office, a realistic planning would be an indispensable element of the project management. In this regard providing the planner of infrastructures with a 3D visualization of the site environment would be of a great asset. Having a glance of the planning area would help the engineer to avoid passing the traffic line through inappropriate locations of the terrain or protected areas and end up in an optimum solution for very elementary steps of axis planning. For this purpose a linked 3D overview which convoys the planning supports the simulation of the construction site and guides in finding the best location. After detailing and embedding the detail plan inside the terrain model optimal height of the structure can be found by balancing cut and fill of soil. Vertical and horizontal sections and profiles at critical points of the plan can assist the planner to make the optimal decision and manipulate, change or review the plan if necessary. Integration of all information will only be successful if it can be treated in a coherent way that allows a seamless interoperability between planning and visualization tools. The approach has to translate the databases in such a way that no information loss happens.



Connection and translation of OKSTRA and GIS data in a temporary database

Approach

Attempting to establish a connection between OKSTRA database (the German standardized data structure for traffic infrastructures of road and railway design systems, e.g. ProVI and the graphical environment represented in GIS, e.g. ArcGIS which provide the best combination for raster and vector data interaction; all online in a link-database; is one of the basic challenges of the work. Second part concerning integration of the ProVI-data with the satellite or aerial raster images which provide the most actual information of the project site for the remote office and feeding the 3D height information of the terrain for an accurate 3D visualization and in addition performing all the error handling, debugging, upload and realization graphical process in less than seconds would be one of the most important aims of this work.

These all implements and customizes a transformation concept between available graphical environment of ArcGIS and mathematical environment of AutoCAD based ProVI so that the transaction and integration of data in these two environments runs information loss. The implementation should be exploitable straightforward by planners to apply an online control model during planning, e.g. for management of time, cost, optimum alternative solution for the best decision making.

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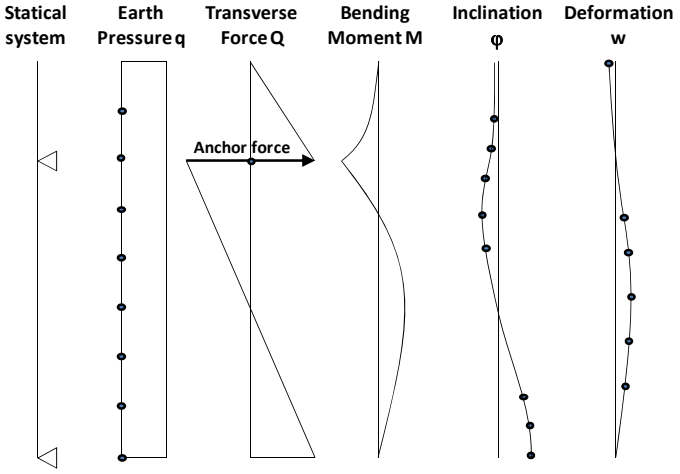
[1] Currently working at the consultancy Obermeyer Planen + Beraten GmbH in Munich.

Consideration of Physical System Dependencies to Prioritize Model Candidates for Simulation-based System Identification

Gerald Faschingbauer

Objectives

This work is dedicated to the construction-simultaneous identification of realistic mechanical models that represent physical effects recorded by measurement instruments. Continuous system identification is the pre-requisite for construction-simultaneous, reliable diagnosis of the actual condition of soil, geotechnical structure and surrounding area. 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. Model candidates will be sampled by deterministic variation of soil law and soil parameters and the system reaction will be simulated with each of those model candidates. Beyond computational efforts, the high number of model candidates required for this approach and the arising amount of simulation results is hardly manageable by the responsible engineer. In order to reduce the complexity and to provide a manageable basis for the engineering decisions, the automatic prioritization of model candidates is mandatory. Therefore a sophisticated model metric will be developed, that facilitates automatic prioritization of model candidates based on quantifiable criteria.



Differential system dependencies of physical quantities

Approach

The example in the figure above shows that the measurement of the inclination brings a considerable gain of information particularly at places where the deformation is hardly measurable, since it shows significant values there. For the measurement of the bending moment no gauges of practical interest are available, however, through measuring of the anchor force, the discontinuity of the transverse force curve can be quantified. Only through the interpretation of these physical quantities in their entirety an essential contribution to system identification can be expected. As the various quantities and their measurement methods show different impact and reliability on system identification, their contribution to the distance measure should be appropriately weighted. Therefore the influence of normalization and weighting of physical values of interest will be investigated and a problem-specific model metric for prioritization will be developed. The envisaged methodology will in particular consider the following four aspects: (1) estimation of the confidence of measurements based on the confidence level following standard stochastic methods, (2) quantification of the confidence of simulated values utilizing the model and parameter uncertainties of the mechanical models according to the model code developed by the Joint Committee on Structural Safety (JCSS), (3) estimation of the significance of measured physical values for system identification according to the differential dependencies of the investigated soil-structure-system, (4) consideration and weighting of the cumulated measurements recorded over the whole construction process. Finally a methodology for prioritization will be developed that considers reliability of measured and simulated values as well as the significance of specific physical values and the influence of the different construction phases. This research work is part of the GeoTechControl project.

Decrease the computational expense of grid computing in geotechnical engineering

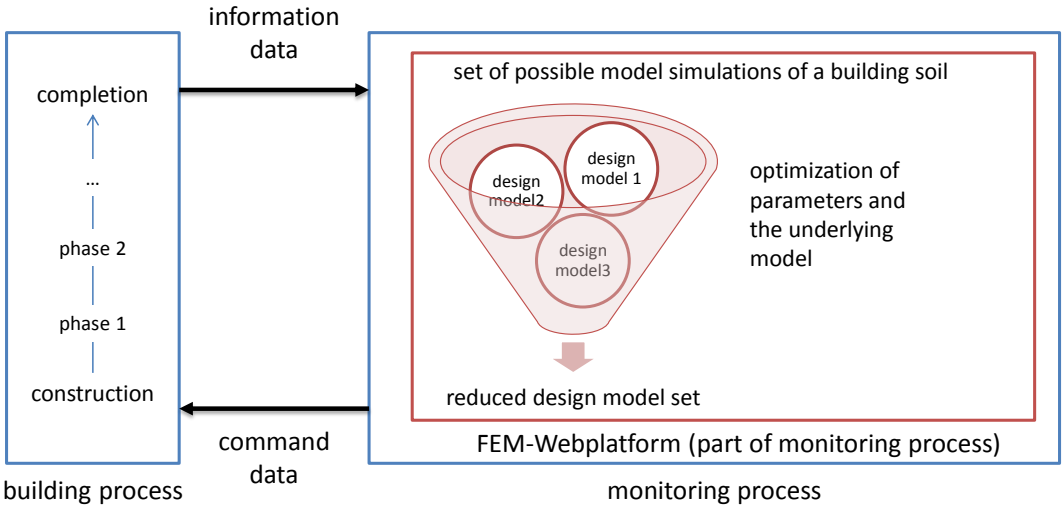
Frank Opitz

Objectives

Geotechnical engineering in complex construction projects require continuous monitoring in the construction progress, i.e. tunnel construction. To reduce or avoid soil settlement a design model is modeled before start of construction to simulate the soil behavior in consequence of the excavation of the ground. After the start of construction different measuring points provide data so that the construction supervisor is aware that there have to be done some change of the structural system of the building pit and potentially adjust the geotechnical simulation model.

The geotechnical design model created by the engineers in the design phase is today often used throughout the whole construction time. Changes in the real soil don't affect the soil model fast enough to make key decisions in time to protect the resulting building and all direct and indirect involved structures from the negative consequences. The methodology of a continuous system identification that is embedded in the overall process of construction data acquisition combined with a continuous adjustment of the simulation model provides a faster reaction and hence accomplishes a higher level of human and environment safety.

To validate the current simulation model and to predict changes of the building pit a large amount of data is accumulated through intensive monitoring so that a pre-processing filtering of the measuring point data and a post- processing filtering of the calculation data is essential.



Reducing process embedded in the overall process

Approach

The processing system, the grid-system, consists of a great number of different web-services, data-stores and a user interface (a system-generated webpage). Performing calculations is a protracted process with the result of a large amount of data. Since even using grid/cloud computing facilities only limited resources are available and the human receptivity is also restricted, the need of smart and wisely limitation of the result set is an essential task.

In order to solve this problem two procedures are necessary. First a pre-processing filtering of the measurement-data is done in order to reduce the FEM-based simulation models and second a semi-automatic engineer-assisted decrease of the parameter set, i.e. specific values of the ground, is applied to minimize potential variations of the analytical model.

The automated optimization process of the grid-system is administrated by the engineer in charge or by the grid-system itself. In order to react to possible hazards in time, all solved FE-results must be filtered too. A way to organize the analysis of the results is to order them by probability of occurrence, of failure and by risk level. This research work is part of the GeoTechControl project and can be reused in related projects.

Research Contracts

Title: **mefisto – A model, information and knowledge management platform in AEC**
(mefisto – Eine Modell-, Informations- und Wissensplattform im Bauwesen)
http://www.mefisto-bau.de

Project Leader: Prof. Dr.-Ing. R. J. Scherer
Co-leader: MSc S.-E. Schapke, Dr.-Ing. P. Katranuschkov

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: 3.5 years, 4/2009 to 10/2012

Approach: **mefisto** is a BMBF lead project in construction ICT that aimed 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, construction site, construction organisation, 2: work grouping, schedules, costs, 3: risks and uncertainties, 4: information management ontologies). Interoperability of the modelling data is achieved via a common platform ontology, a newly developed multi-model 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 are 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 process configuration methods and services as well as available sophisticated systems for construction management, controlling, geometry modelling and simulation, which were extended during the project, mefisto achieves:

- 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 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 is 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 is 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: Institut für Informatik im Bauwesen

Title:	**HESMOS – ICT platform for holistic energy efficiency simulation and lifecycle management of public use facilities** http://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 (CO_2) 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 simulations can be easily done in all design, refurbishment and retrofitting phases where the largest energy saving potentials exist. This is 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 energy related design parameters of buildings and their surrounding areas, and (6) integrating BIM and Building Automation System (BAS) data and querying these multi-model data with the help of a high-level engineering language. The final 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. To achieve that, an innovative SOA around the kernel functionality of BIM-based CAD/FM is applied. Information interoperability is provided by enhancing BIM with multi-model energy and emissions features to a new sharable eeBIM. Intelligent multi-model access and processing methods and a specialised ontology are 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. Such methods include various possibilities for filtering the BIM data on class, grouping, topology and instance level, fully IFC-compatible space boundary level 1 to level 2 conversion, transformation of eeBIM data to input simulation model data, coherent post-processing for both simulation and BAS data etc. To validate the research results and expedite their uptake in practice, an extensive 30-month validation programme at two PPP projects (a professional school complex in Pforzheim and an office building in Kassel, Germany) is carried out during the project.
Partners:	TU Dresden, Institut für Bauinformatik – **Coordinator**, TU Dresden, Institut für Angewandte Informatik, Institut für Bauklimatik 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)

Title:	**ISES – Intelligent Services for Energy-Efficient Design and Life Cycle Simulation** http://ises.eu-project.info/
Project Leader:	Prof. Dr.-Ing. R. J. Scherer, Co-leader: Dr.-Ing. Peter Katranuschkov
Financial Support:	EU
Budget/Funding:	4.4 million Euro / 3.0 million Euro (total), 0.6 million Euro (CIB)
Duration:	3 years, since 12/2011
Approach:	**ISES** develops ICT building blocks to integrate, complement and empower existing tools for design and operation management (FM) to a Virtual Energy Laboratory. This will allow evaluating, simulating and optimizing the energy efficiency of products for built facilities and facility components in variations of real life scenarios already before their realisation. A special aspect is the stochastic modelling of the life-cycle. The focus of the prototype application domain is on buildings, factories and warehouses because in buildings about 40% of the global energy is used and 30% of CO_2 emissions and solid waste is created. There is a huge market for more energy-efficient design of new buildings and for refurbishing of the huge building stock through energy-efficient component products. A particular goal of the project is to increase, by an order of magnitude, the quality of energy-efficiency in design through the development of an In-Silico Energy Simulator Laboratory, based on an interoperable ontology-supported platform customizing advanced Grid and Cloud technologies. The focus of the research is on multi-model design and testing, stochastic lifecycle analysis/simulation in combination with new supporting ontology and interoperability tools and services, and respective re-engineering of existing tools, making them more intelligent and smartly interoperable. Further goals are the combination of energy profile models with product development STEP models and building and facility BIM models. The developed Virtual Energy Lab will be an extension of the platform achieved in the HESMOS project. It will be configured as an ontology-controlled SOA system with distributed services, distributed modelling and analysis/simulation tools and distributed data sources. This will allow concentrating the RTD work on ICT gaps, whereas existing, market-proof services, tools and data sources can be incorporated nearly development-free.
Partners:	TU Dresden, Institut für Bauinformatik – **Coordinator**, Olof Granlund Oy (Finland), University of Ljubljana (Slovenia), Nyskopunarmidstod Islands (Innovation Center Iceland), SOFiSTiK Hellas S.A (Greece), National Observatory Athens (Greece), Leonhardt, Andrä und Partner (Germany), Trimo d.d. (Slovenia)

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 / 0.9 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 is 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

Title:	**SE-Lab - A Cloud-/Grid-Based Virtual Laboratory for Non-Linear Probabilistic Structural Analysis**
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. G. Faschingbauer
Financial Support:	EU – Eurostars Nr. E!7521; BMBF (German Ministry of Education and Research)
Budget/Funding:	1.2 million Euro / 0.8 million Euro (total), 0.46 million Euro (CIB)
Duration:	3 years, since 12/2012
Approach:	**SE-Lab** is an innovative combination of (1) sophisticated mathematical methods from computational mechanical and probabilistic engineering (2) computer science methods from public cloud and private grid and web service technologies, and (3) construction informatics methods related to Building Information Modelling (BIM), in particular engineering information management, filtering, interoperability, model mapping and model change propagation. More slender structures, new architectural design paradigms, retrofitting of cultural heritage, life-cycle consideration of civil engineering structures and an increased demand for safety in the society require broader application of advanced non-linear mechanical modelling and probabilistic safety concepts for structural design. This, in turn, calls for advanced information management and automation of the mass of simulations needed for well-grounded design variations and probabilistic evaluation, and hence for much more computer power. The partial safety factor approach that is commonly used today cannot be applied in combination with structural non-linear analysis and has to be replaced by the full probabilistic approach. In addition, for non-linear structural analysis the linear superposition principle is not valid, which means that for multitudes of load combinations separate non-linear analyses must be carried out. The use of currently available tools for such purposes exceeds the labour resources and the computer power of SMEs in the construction domain. Therefore new integrated methods are needed. SE-Lab is developing an IT environment, which is fully BIM-integrated with the architectural CAD design systems. It will allow carrying out the huge amount of structural analysis tasks required for the realisation of the outlined full probabilistic non-linear approach without significant additional efforts of the designers. Moreover, it will offer the possibility to inspect any individual analysis run in 3D on demand, to study crack and failure mode propagation and hence to obtain in-depth understanding of the structural behaviour in order to find the optimal structural design. The developed platform will be applicable to all engineering structures, like steel, re-enforced concrete, composite, geotechnical and glass structures and components. It will be an information management platform on web service basis where all computational and graphical tools are plugged in via web-service wrappers. No specific tool will be preferred, each will be exchangeable and there will be no tools to which SE-Lab is limited. The stochastic developments will be based on the newly proposed international probabilistic safety standard, the fib model code 2010 to achieve maximum international acceptance. Various specific national guidelines can later be added on demand due to the flexible SOA structure of the SE-Lab platform.
Partners:	Cervenka Consulting, s.r.o., Prague, Czech Republic Leonhardt, Andrä und Partner, Beratende Ingenieure, VBI, GmbH, Germany TU Dresden, Institut für Bauinformatik

Title:	**Trans-IND – New industrialised construction process for transport infrastructures based on polymer composite components** http://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); MIKROSAM (FYR Macedonia), Institut für Verbundwerkstoffe GmbH (Germany), Labein Tecnalia (Spain), 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 (Spain), TU Dresden, Institut für Bauinformatik

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)* http://www.geotechcontrol.de/
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. 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

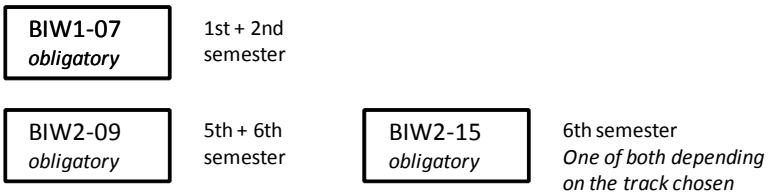
Title:	**eWorkBau – Webservice-based multi-media teaching and learning concept for craftspeople's training in mobile model-based working methods** *(eWorkBau – Webservice-basiertes multimediales Lehr-/Lernkonzept für die bauhandwerkliche Aus- und Weiterbildung für die mobile modellbasierte Arbeitsweise)* http://www.geotechcontrol.de/
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. 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, since 01/2012
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:	**Campus-Navigator – The guidance system of the TU Dresden**
Project Leader:	Dr.-Ing. habil. 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 university administration. **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.

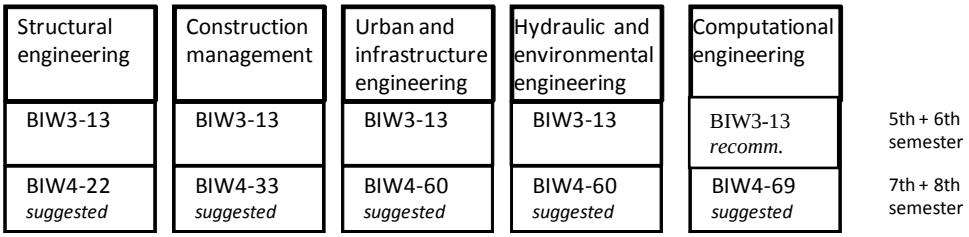
Lecture Activities

Since 2006 the students can choose construction informatics as a competence subject in their curriculum. This means that in the 4-semester Diploma course (equivalent Master Courses), 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 recommended as the starting module, namely BIW3-13 "Construction Informatics – Fundamentals", whereas the other one can be chosen out off the remaining four (BIW4-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 as preparatoring module and introduction module to Building Information Modelling (BIM) and 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 Information Modelling (BIM) 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 holistic views and BIM 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/Kadolsky

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/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/Windisch

Subject: Through the two courses of this module the students acquire basic and advanced BIM 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/ Kadolsky

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.

Publications in 2012

[1] GÖKÇE K. U., GÖKÇE K. U.: Integrated ICT Architecture for Energy Efficient Buildings. Construction2012 Research Congress, West Lafayette, IN, USA, 21-23 May 2012.

[2] GÖKÇE H. U., GÖKÇE K. U.: Integrated ICT Platform for Energy Efficient Smart Cities. Construction2012 Research Congress, West Lafayette, IN, USA, 21-23 May 2012.

[3] BENEVOLENSKIY A., ROOS K., SCHERER R. J.: Using Rules for the Configuration of Construction Processes. In: Proceedings of the ICCCBE 2012, Moscow, Russia, June 2012.

[4] PRUVOST H., BENEVOLENSKIY A., SCHAPKE S.-E., SCHERER R. J.: Considering Project Risks in Reference Modeling of Construction Processes. In: Proc. International Workshop: European Group for Intelligent Computing in Engineering (EG-ICE), Herrsching, Germany, 4-6 July 2012.

[5] WINDISCH R., KATRANUSCHKOV P., SCHERER R. J.: A Generic Filter Framework for Consistent Generation of BIM-based Model Views. In: Proc. International Workshop: European Group for Intelligent Computing in Engineering (EG-ICE), Herrsching, Germany, 4-6 July 2012.

[6] GÖKÇE K. U., GÖKÇE H. U., SCHERER R. J.: A Methodology to Define Generic IFC Views in the Construction Management Domain. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Iceland, 25-27 July 2012.

[7] GÖKÇE K. U., GÖKÇE H. U., SCHERER R. J.: A Methodology to Integrate Construction Management Phases and Processes. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Iceland, 25-27 July 2012.

[8] GURUZ R., KATRANUSCHKOV P., SCHERER R. J., KAISER J., GRUNEWALD J., HENSEL B., KABITZSCH K., LIEBICH T.: Ontological Specification for the Model Integration in ICT Building Energy Systems. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Island, 25-27 July 2012.

[9] KOG F., SCHERER R. J., DIKBAS A.: Petri Net based Verification of BPMN Represented Configured Construction Processes. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Island, 25-27 July 2012.

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[11] BAUMGÄRTEL K., KATRANUSCHKOV P., SCHERER R. J.: Design and Software Architecture of a Cloud-based Virtual Energy Laboratory for Energy-Efficient Design

and Life Cycle Simulation. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Island, 25-27 July 2012.

[12] TAUSCHER H., SCHERER R. J.: Towards a Configurable nD-viewer for Building Information Models: A Generic Model for the Description of Visualization Methods. 9th European Conference of Product and Process Modelling (ECPPM), Reykjavik, Island, 25-27 July 2012.

[13] WINDISCH R., WÜLFING A., SCHERER R. J.: A Generic Filter Concept for the Generation of BIM-based Domain- and System-oriented Model Views. 9th European Conference on Product and Process Modelling (ECPPM), Reykjavik, Iceland, 25-27 July 2012.

[14] WINDISCH R., SCHERER R. J., PAPPOU T., GISAKIS A., PROTOPSALTIS B.: Virtual Wind Laboratory for the Aerodynamic Analysis of Building Structures. 9th European Conference on Product and Process Modelling (ECPPM), Reykjavik, Iceland, 25-27 July 2012.

[15] LIEBICH T., STUHLMACHER K., GURUZ R.: Information Delivery Manual Work within HESMOS – A Descriptive Approach to Defining Information Delivery Manuals. Registered with BuildingSMART, IDM registration form by Jan Karlshoej, 31 July 2012.

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[18] BAUMGÄRTEL K., KATRANUSCHKOV P., SCHERER R.J.: Analyse und Entwurf eines virtuellen Labors zur Unterstützung von parallelen Energiesimulationen (Analysis and design of a virtual lab for the support of parallel energy simulations). In: Proc. 3rd Fachkonferenz Bauinformatik – Baupraxis 2012 “Industrieforschungsprojekte in der Bau-IT”, Dresden, Germany, 21 September 2012.

[19] FLEMMING C., FUCHS S.: Verbesserung der Prognose von Zahlungsplänen durch Multimodell-Filterung und 4-Stufen-Risikosimulation (Improving the forecasts of payment schedules using multi-model filters and a 4-staged risk simulation). In: Proc. 3rd Fachkonferenz Bauinformatik – Baupraxis 2012 “Industrieforschungsprojekte in der Bau-IT”, Dresden, Germany, 21 September 2012.

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[25] HILBERT F., SCHERER R.J.: Context-specific Multi-model-template Retrieval. In Proceedings of the Working Conference on Virtual Enterprises, PRO-VE 2012, Bournemouth, GB, October 2012.

[26] SREWIL Y., KADOLSKY M., SCHERER R. J.: Integrating RFID Technology in Dynamic Construction Process Planning. In: Proc. of the 29th CIB W78 2012 International Conference, Beirut, Lebanon, 17-19 October, 2012.

[27] BENEVOLENSKIY A., ROOS K., KATRANUSCHKOV P., SCHERER R.J.: Construction Processes Configuration Using Process Patterns. In: Advanced Engineering Informatics, Volume 26, Issue 4, October 2012.

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)	Intl. Council for Research and Innovation in Building and Construction (CiB)	The Netherlands
Construction Innovation	Emerald Group Publishing	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