INSTITUT FÜR BAUINFORMATIK
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TECHNISCHE UNIVERSITÄT DRESDEN

RESEARCH AND LECTURE ACTIVITIES IN 2014

December 2013

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 2014. Research topics are: building information modelling, multi-models, interoperability, generic model filters, intelligent construction management, virtual organizations, project risk management, dynamic process modelling, simulation, e-learning, and design, construction and operation of energy-efficient buildings. Most of the topics have been accumulating in our new common development "An intelligent Virtual Engineering Lab (iVEL), which bridges the BIM-CAD world with the computational engineering world, providing simulation power to planners, designers and operators. Underlying basic methods and technologies are: object-oriented modelling, process modelling, ontologies, description logic, service-oriented architectures, grid and cloud computing, stochastics and vulnerability.

2013 was very successful in gaining research results and acquiring new research projects, in particular in ICT for energy-efficient buildings. The Mefisto project results have been exploited in industry and standardization concerning multi-models (MM), construction site simulation, multi-media visualization, interoperability and risk management. A book of the Mefisto results will be published at Springer in mid of 2014 The first versions of our multi-model BIM tools has gone online and can be reached at (*http://mefisto-bau.de/resources/resources_software.html*), namely the filter toolbox BIMFIT and the multi-model container viewer and manager M2A2 and the construction simulation toolkit CST. Further tools like Billie, the multi-media visualizer, and BIMcraft, the craftsmen's information access tool, are about to be published soon. The multi-model container method and the lean IDM interoperability method have been adapted by buildingSMART for recommendation and standardization. The first MMC group met in the middle of October 2013. Shortly before, on 1st Oct. 2013 the first VDI working group for BIM met and decided to develop a multi-model BIM application guideline. Our new flagship development iVEL, which comprises everybody's research results but as a whole makes up quite more than the sum of its single constituents, might be the ground on which successfully acquisition of new research project has based, resulting in 3 EU projects on holistic ICT methods for energy-efficient buildings: eeEmbedded, HOLISTEEC and Design4Energy started on 1st Oct. 2013 for a 4-year duration each, and one Eurostars project: BridgeCloud started on 1st July 2013 for a 3-year duration. Further, on 1st Jan. 2013 the EU project SE-Lab started. Each of them is focused on iVEL and BIM, at least the TUD part. This makes us hope that iVEL will further be developed substantially.

The institute strongly promotes ICT in research and industry. Prof. Scherer is chairman of the European Association of Product and Process Modelling, which will hold its 10th ECPPM conference in Vienna, Austria, from 17th-19th September 2014 (*http://www.ecppm.org*). The ECPPM started in 1994 and is the oldest BIM conference. The preceding one in Reykjavik 2012 was one of the most successful one with over 150 participants and over 120 papers. In conjunction with the 10th ECPPM, the 5th Workshop on ee-Building Data models will be held, which underpins the importance of BIM methods for energy-efficient design and maintenance of buildings.

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 September 2013, the institute organized 4th conference "Bauinformatik – Baupraxis" (construction informatics – construction practice) in Dresden, supported by the "Dresdner Bauinformatik-Gesprächskreis" (Dresden Construction Informatics Roundtable).

E-learning activities have been extended with the project eWorkBau, which focuses on the interfaces for BIM access and a domain-oriented BIM query language, both embedded in e-learning courses. The European on-line master course "IT in Construction", co-ordinated by the University of Maribor, Slovenia, is now in its 10th academic year and students can enrol at 7 European universities.

In July 2013, Gerald Faschingbauer left the institute for the industry. Together with Sven-Eric Schapke's going in 2012, we lost high competence in applied ontologies, multi-modelling and BIM. They both have taken over leading positions as leaders for the development of BIM in German software companies. Additionally, Amin Zahedi is going to leave the institute for his home country, Iran at the end of 2013. His work will be taken over by Herve Pruvost and Frank Noack, On the other side, 7 new co-workers have joined the institute to strengthen and rejuvenate our team: Jamshid Karami, Robert Kreil, Michael Polter, Eko Nityantoro, Mario Gürtler, Marc Mosch and Frank Noack. Ksenia Roos has successfully managed to continue work on her PhD as member of the institute. All in all, the employees at the institute cover a broad range of expert domains as well as languages with researchers from Bulgaria, France, Iran, Russia, Indonesia, Syria and Turkey.

Collaborative research has successfully been continued in 2013. Prof. Thomas Froese from the Canadian University of British Columbia at Vancouver, who is active in construction management informatics, stayed at the institute for about two fruitful weeks in August, and Prof. Matevs Dolenc from the Faculty of Civil and Geotechnical Engineering of the Slovenian University of Ljubljana, who is active in construction informatics, had a 3-month stay for in-depth research at our institute from August through November.

The PhD student Denis Smirnov from the Saint-Petersburg State Polytechnical University worked with us for a 3-month period, supported by the DAAD. Together with Alexander Benevolenskiy he developed an ontological knowledge case-base for building renovation. Moreover, the institute hosted 4 students from the Lebanese American University for a 6-week period, who gathered experience in construction informatics research.

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

Dresden, in December 2013 Raimar J. Scherer

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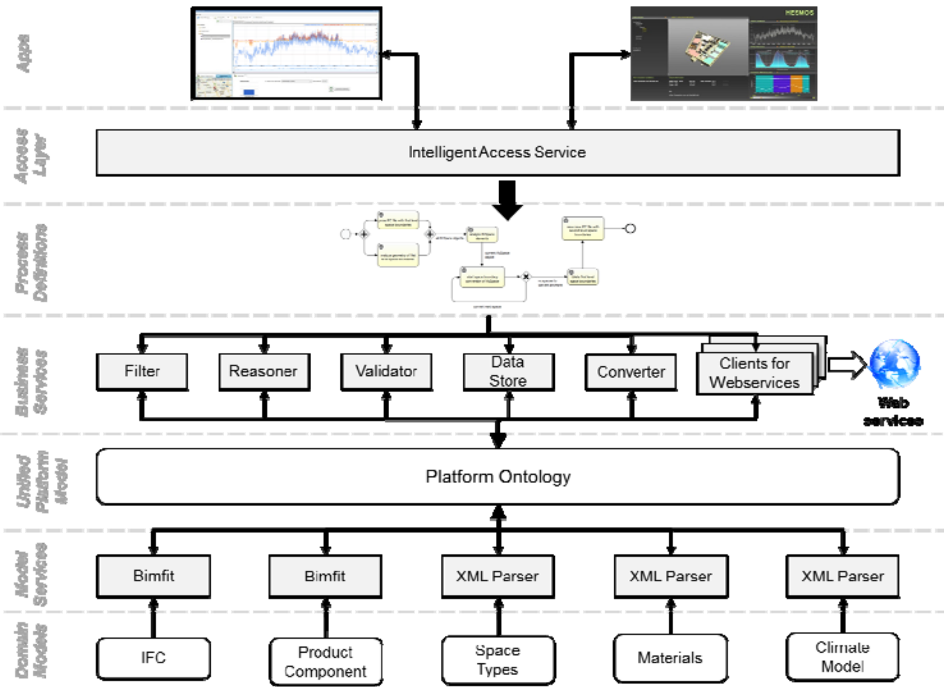
Overall the employees at the institute cover a broad range of expert domains as well as languages with researchers from Bulgaria, France, Iran, Russia, Syria, Indonesia and Turkey.

Multi-Model Integration Supported by Ontologies

Ken Baumgärtel

Objectives

When following the building information modelling approach not only many users are involved but also many different data models like material data for building elements, activity templates for room and climate templates for buildings exists. All of these data is represented in own data formats through different models. For example, the building information model based on the standardized IFC is used for the representation of the architectural model. While this is very good for representing semantic information within the model, e.g. the relationship of building elements to rooms, there is a big problem how to combine and connect to external data, e.g. occupancy templates to rooms or climate templates to the building, to gain a higher semantic level for tasks like energy simulations.



Integration process of multiple domain models in central ontologies

Approach

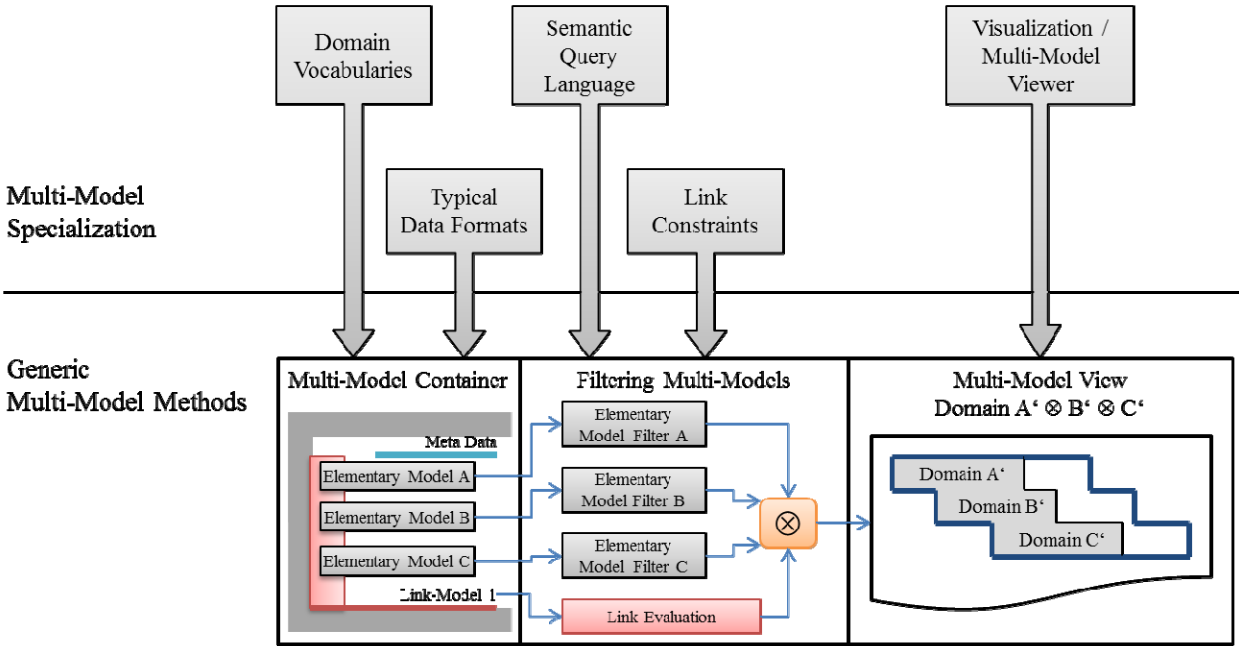
The multi-model integration approach is divided in seven layers to enable generic and flexible integration steps. The purpose of this approach is to provide the original data on the fly and to keep the original data structure as it is while working on domain specific information which will be exported to generalized and easy to extend ontology models. In the first layer at the bottom of the figure above different domain models are stored in their own data format e.g. IFC, template data or product catalogue data. Model services, represented in a second layer, will interpret these models and provide the knowledge how to read, modify, filter and serialize the models. Such model services can be BIMfit for IFC or other STEP-based data or XML parser which can read template data based on XML etc. One of the most important layers is the unified platform model layer which provides domain ontologies. These models include semantics about the different domains where the basic models are used for. For instance, in energy-related tasks like thermal simulations the knowledge what is a zone and how it is used by energy experts is represented through ontology rules and energy domain constraints. Several business services are using this information to make inferences, validations, pre-checks and conversions based on process definitions of the end users. A general interface layer provides access to this combined information formatted for the specific work of the end user like simulation configuration and data visualization. Finally, desktop application or web applications represented in the top layer have access to this highly enhanced data so that it facilitates the work of each involved user. The integration process represents a step-by-step enrichment of the semantics which are provided in the original data models but are not fully prepared for the purposes of the end users. This research is part of the European projects ISES and eeEmbedded.

Multi-Model Specialization for Domain Specific Applications

Sebastian Fuchs

Objectives

The multi-model methodology is an approach to manage structural data exchange problems in interdisciplinary construction information processes. Multi-models combine heterogeneous models of different domains and allow the connection of their elements in external ID-based link models. Methods for creation and evaluation of links are already developed, basing on that structure. In order to provide a potential solution for *any* cross-domain problem, the multi-model concept is generic and designed to be extended for specific data formats. Hence it is essentially a technical system and has no semantics for the construction (or any other) domain itself. Though it is possible to express certain domain semantics as criteria statements using the Multi-Model Query Language *MMQL* – a comprehensive method to integrate construction specific semantics with multi-models is still missing. Therefore a method to specialize the generic multi-model approach for certain construction domains, like bidding and award, is to be developed. Benefits are the retention of the multi-model's flexibility and generality on the one hand and the *direct* application to special, cross-domain construction problems on the other hand. Enhancing multi-models with domain specific semantics could unleash the full potential of this interoperability system.



Aspects of multi-model specialization (top) and their appropriate corresponding generic methods (bottom)

Approach

The overall approach of the multi-model specialization is first to restrict the usage of elementary models and links by constraints which reflect the domain's particular semantic. Secondly the human-computer interface must provide only typical domain concepts to the engineer. That's why the domain's specific construction vocabularies must be exposed to users. A vocabulary is usually reflected by the underlying elementary data model too. So the vocabularies, as well as the typical data formats of the domain, influence the selection of valid elementary model types. According to the specific information process, a graphical or textual query language must be used. Syntax, semantics and execution result of the query language have to match the engineer's intention, which is usually about a functional level. Thus engineering languages have to be designed which internally may be mapped to a generic level language like MMQL, which is best for link evaluation. The links' semantics must be definitely declared and stored in a knowledge base or ontology. Constraints have to be set for multiplicity and valid element and model types. The data of multi-model views must finally be presented by novel multi-model viewers which are able to visualize the combined, filtered and linked domain aspects in a useful manner. This research work is part of the project *eWorkBau*, where a prototype is to be developed for the 5D-domain. Moreover the approach will be the base for the newly founded buildingSMART's multi-model standardization project.

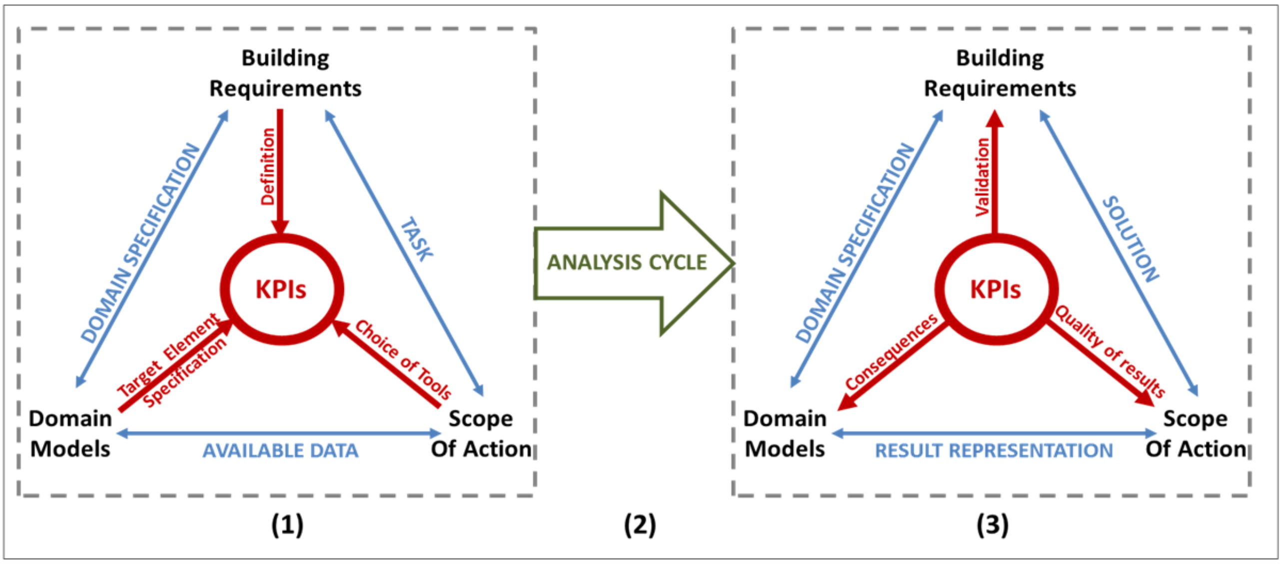
Patterns for a Holistic KPI Driven Design Process

Romy Guruz

Objectives

The objective of this research is the development of a method for the achievement of consistent Key Performance Indicator (KPI) definition on the example of energy-related KPIs as basis for analyses, and their later evaluation for decision making in different dimensions and Level of Details (LoD). This method will allow designers to easily structure the design process in individual evaluable parts and will thus help them to concentrate on high-level strategic decision making tasks.

The biggest opportunity to influence the relationship between energy goals and architectural design is during the early planning phases of a building project. It is commonly known that inefficient design decisions can have substantial negative influence on the economic and the ecologic performance of a building. Great opportunities for improvement are seen in the early design phase, where only general conditions and basic constraints are predetermined by the client and the architect, and where little or no energy expertise is involved in the planning process. This raises the question whether (KPI) can provide the reliable estimate the designer in this stage needs.



3-step design pattern: (1) Initial KPI definition; (2) Analysis; (3) KPI evaluation and decision making

Approach

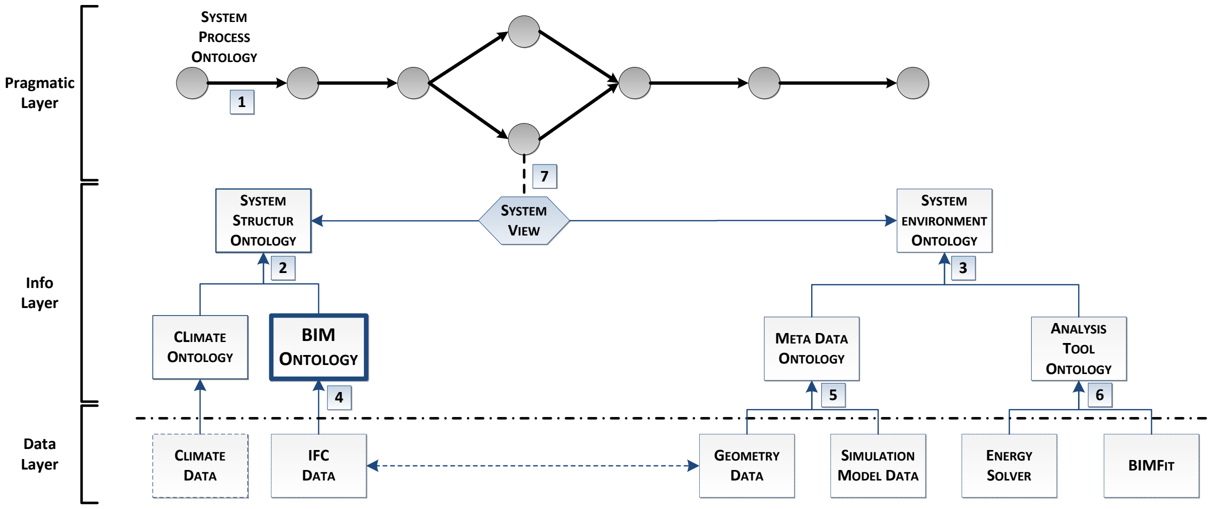
The suggested overall approach comprises three steps. The first step focuses on the formalization of patterns for individual design sections and tasks, fixed by pre-defined KPIs. The second step comprises the analyses of the design, and the third step focuses on the evaluation of the analyses results against the defined KPIs, as an essential support for decision making for the next design steps or even a design revision. The description of building requirements in the first step varies depending on the client, the type and the size of the project. To enable structured definition and formalization of KPIs via rules and/or algorithmic constituents, first the building requirements have to be appropriately categorized. In general, three types of requirements can be distinguished: a) requirements that are quite complicated and fuzzy to represent (because they describe, e.g. an impression like "relations of different views"), b) requirements that allow drawing direct conclusions, such as space use, furniture concept etc., and c) requirements that can be formalised as facts (values, value ranges, rules, fixed algorithms). The formalized KPIs are the target elements for the preparation of the analyses, e.g. conclusions can be drawn with regard to domain models and the related elements and the input model view for the analyses can be prepared. The analysis results are validated against the building requirements. In addition to the consequences for the domain models, the quality of the results should be evaluated here as well. The challenge is to develop an IT and BIM based combination of evaluation and deduced conclusions for the next design steps. To achieve the envisaged functionality, methods are being developed to formalize and resolve each single step in a set of patterns. This KPI driven design process is expected to lead to greater efficiency in the planning procedure to final design results of higher quality. At the same time, it will provide an opportunity of weighing up many more alternatives than currently possible.

Towards a System Ontology for Multi-System Analysis

Mathias Kadolsky

Objectives

The building design process is characterized by the analysis of different engineering systems. These systems are the results of an abstraction process applied on a certain segment of the real world defining the content for a specific engineering task. The system-related content comprises the system concepts, their relationships, system internal restrictions, external boundary conditions and the functional description to formulate the structure and the behavior of the engineering system. Conventional application models used for BIM-based building design like the IFC generally contain no explicit system information hindering a system-oriented modelling and analysis of engineering systems, the assessment of system specific criteria like the system quality and the evaluation of system changes under internal and external conditions. Furthermore, system dependencies describing the interactions between different systems as well as the combination of systems can be only restrictedly modeled. So, in this approach an analysis system ontology is proposed defining systems from a BIM-centered view for supporting system analysis in particular in the scope of energy efficient building design. Thereby, the ontology will not replace or redefine origin models like the IFC. Rather than this, the ontology can be seen as model extension integrating system concepts from BIM-, BAS- or BACS-models and defining new concepts for linking, detailing or composing.



Ontology-based system analysis approach integrating different domain models

Approach

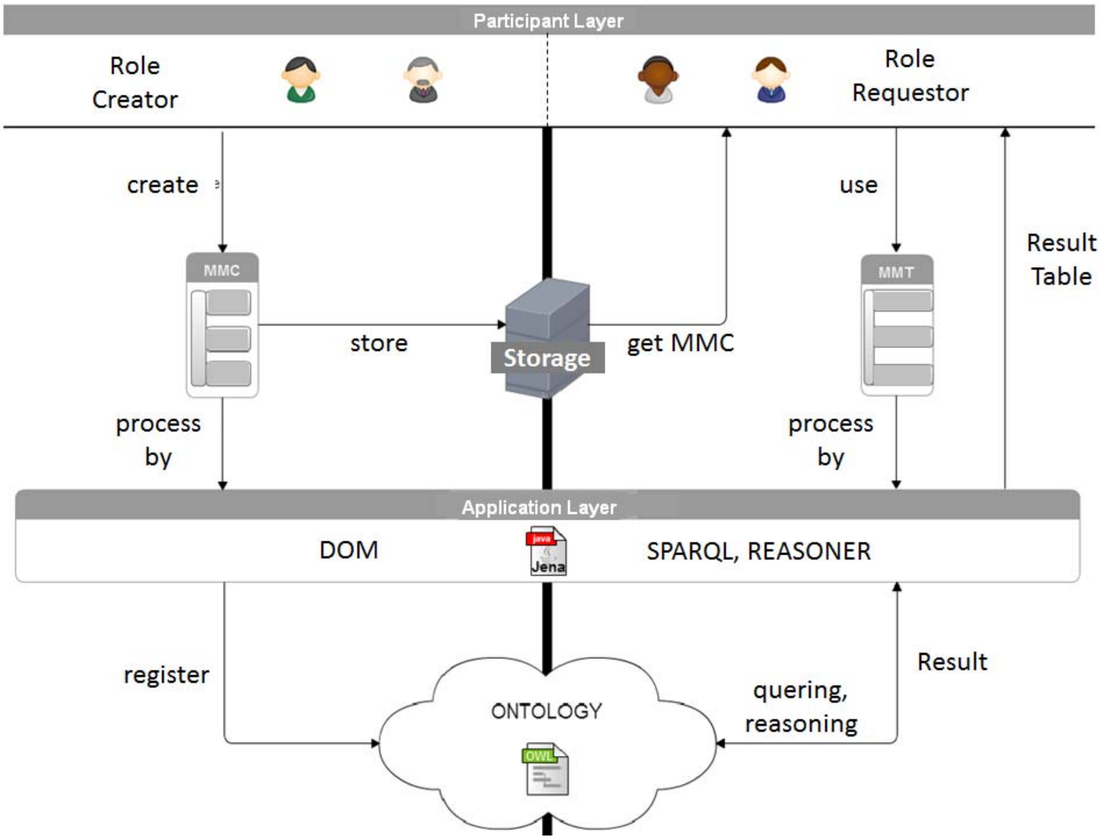
The system ontology approach consists of three specific sub-ontologies: (1) The system process ontology, (2) the system structure ontology and (3) the system environment ontology. The system structure ontology contains the structure information captured from the origin input model data. For this reason, meaningful model content appropriate for a system relevant efficient logical analysis and processing is separated from pure data like geometry data, which is linked in form of meta data. With regard to the building as central analysis object the core of the system structure ontology is built by the BIM-ontology (4). Here, concepts from the IFC were adapted and extended to facilitate linking to other domains like the climate domain. Next to logical analyses and operations for validating and completing semantic structures the energy performance analysis also comprises arithmetic analyses like numerical-based simulations. Therefore, the necessary linked input and output data as well as the necessary tools and services are represented in an abstract manner by the meta data ontology (5) and the analysis tool ontology (6) summarized in the system environment ontology (3). The context, which defines, when which information or service is needed, is formulated in the system process ontology (1). In the sense of a pragmatic layer the process and its process steps define a system view (7) linking a system sub-structure and system environment view with the context within they are used. The elaboration of this approach is part of the research work in the ISES and eeEmbedded projects.

Ontology Supported Recombination of Multi-Models

Eko Nityantoro, Frank Hilbert

Objectives

Current practice in the construction industry is that participants apply their own method to develop their information model, apply software of their preference and hence choose data formats that suit them best. Hence, diversity appears. The concept of multi-models is introduced to handle this diversity partially. By employing multi-models, each participant will be able to collaborate to some extend despite having different resources. Information exchange can be accomplished by using multi-model containers as transport medium. An ontology model is used as a resource to gather, store and manage the meta-information about the multi-models. As a part of Semantic Web technology, the ontology is able to describe the meaning of each multi-model. Furthermore, it creates the possibility of inferring information to a logical pattern. With this ability, the ontology can support participants to retrieve information they need much more properly and precisely than object or relational data structures would allow.



General Scenario for ontology supported Collaboration using Multi-models

Approach

Two scenarios will be introduced in this section. The first scenario is to register a new elementary model inside a Multi-Model container (MMC) into the Multi-Model Ontology (MMO). The second scenario is to get the information from MMO about the existence of required elementary models as shown above. It is assumed that each participant has the same role to create and request meta-information about an elementary model.

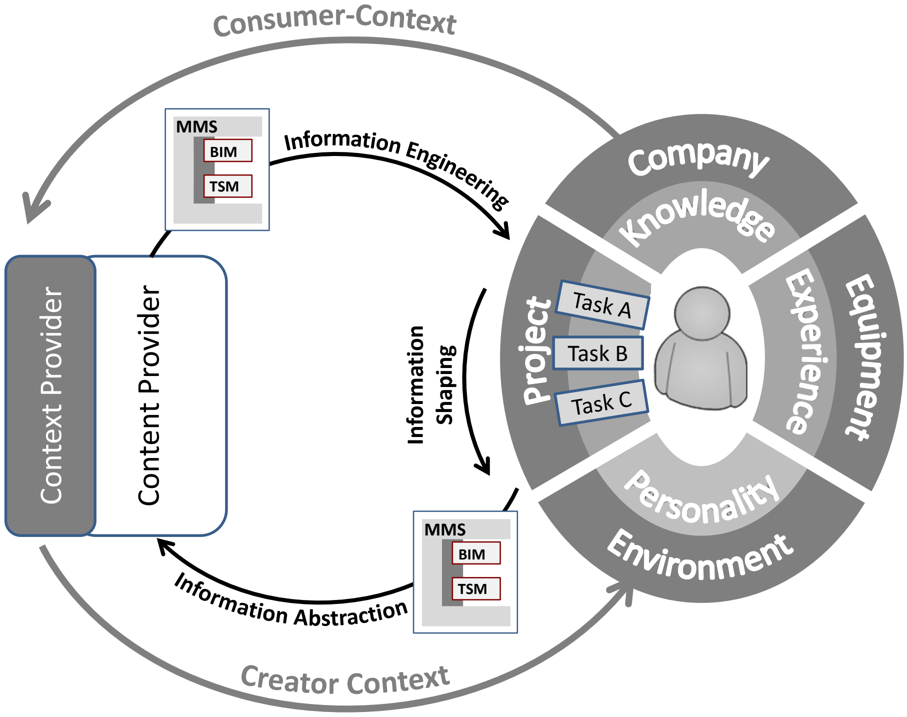
Beside creating and requesting, project participants also have to store their created elementary models in a particular storage, which can be accessed by other participants. They should provide the information about the storage URL when registering the new elementary model. It is important to keep in mind that all elementary models are bundled in a multi-model container. An MMC consists of one or more elementary models, such as BIM, Cost-Pricing, Scheduling. Each Elementary Model can be in different file formats such as ifc, cpixml, gaebxml, or plain xml. All participants have to have approved these different kinds of file formats as a readable format in their systems at forehand. Along with the agreement of the format, it is also important to have an agreement regarding the vocabulary, which includes languages, abbreviations, etc. This research work is part of the eeEmbedded project triggered in the Mefisto project.

Context Sensitive Information Spaces for Efficient Information Delivery

Frank Hilbert

Objectives

The collaboration in construction projects is still hindered by the heterogeneity of engineering and management information models. In addition the specialization of the project partners results in domain specific semantics. Always a substantial number of project partners collaborate on different, interdependent application models. Both the amount and variety of all, and the scope and complexity of individual application models are constantly growing. This is due to increased demands on the structure (e.g. environmental impact, wind and climate calculations), the technically demanding and expansion, extension of restrictions and legal requirements and long term objectives of the comprehensive use of product models (e.g. at facility management). For many cross-model tasks (e.g. bid preparation) only specific subsets of the available information is needed. Search for such relevant information complicates the collaboration in the project. Against the background of this situation and the expected further increase of the data volume the purposeful delivery of relevant information becomes increasingly important for project success. In this approach, context information will be used to support the collaboration in construction projects by generating purposeful information spaces.



Information space Generation using Context Information

Approach

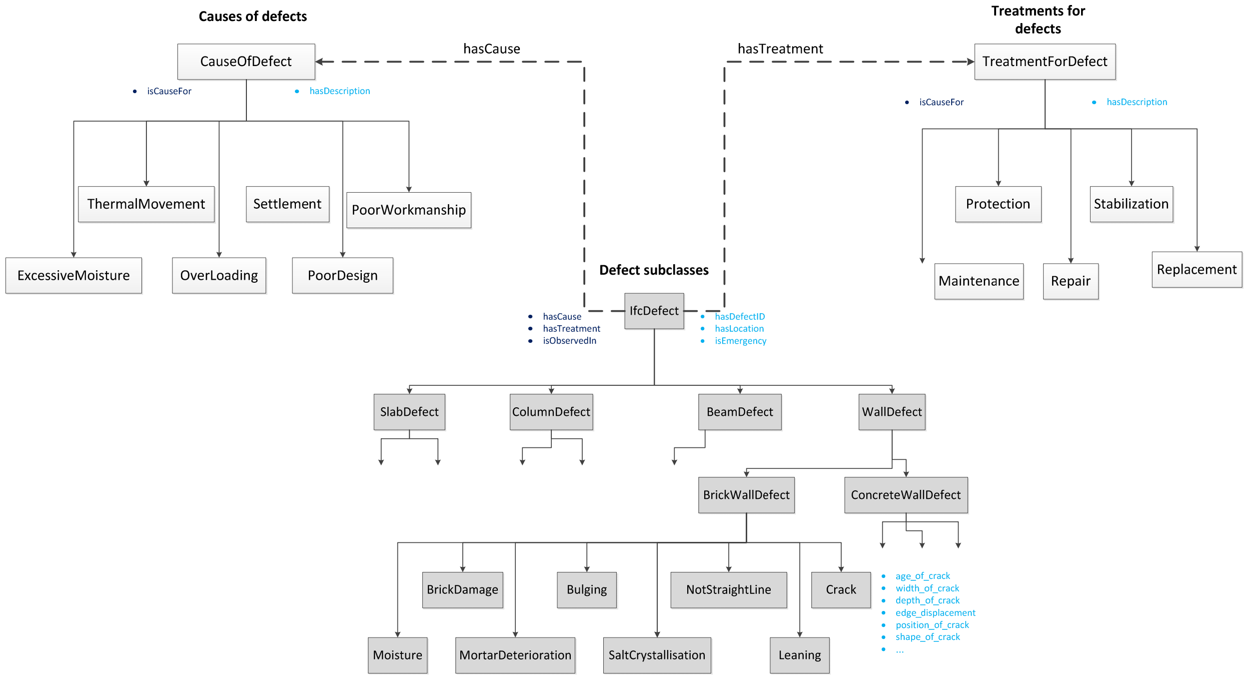
The goal of a context sensitive information supply in Construction is to prepare application models according to the information needs and to provide them to the actor in a suitable form. The various information processes in the context of a construction project generate a different information requirement, which depends on the actor and its context (task, role, experience etc.). This information requirement can be satisfied by multi-model-based information spaces (MMS). Therefore the multi-model template approach (MMT) can be used, to describe the information requirement. To determine the information requirement the user context needs be suitably formalized and additional rules are needed that determine the effect of different context aspects to the information needs. For this, the description language OWL is used and an ontology Reasoner can determine the information needs. According to the information needs of the appropriate information for the provision of information can be found and a context-specific information space can be generated. This will be delivered to the actor additional to the task description to be processed (push principle). In this manner context information about the situation of model generation and the situation of model usage describes metadata as well as information needs. Focused on this context information, this approach allows generating specific information spaces, which provide exactly the information needed by the actor in the situation.

Ontological Knowledge Case Base for the Assessment of the Building Elements

Alexander Benevolenskiy, Denis Smirnov

Objectives

The renovation of the old buildings is nowadays a very actual problem for many European cities. Assessment and analysis of existing building structures are one of the most important and difficult parts of any renovation projects. Current methods for assessment are proved to be too conservative, very time-consuming and expensive and therefore new approaches and technologies are required in this field. One of the possible solutions that can improve and accelerate the assessment process is the use of an extended case-based reasoning system. The objective of this work is the development of a methodology and a knowledge-base for such a system.



Ontological knowledge case base

Approach

Case-based reasoning systems have found their application today in many different areas. They are designed to solve new complex problems based on the solutions of similar problems in the past. In the current approach a use of an extended version of a case-based reasoning system is proposed in which not a pure case base will be modeled, but rather some extension of it, a so called "knowledge case base". This knowledge case base can be seen as a combination of a knowledge base and a case base, which brings the advantages of both approaches together. This knowledge case base can be used not only for storing cases, but also for reasoning on them. In this work an ontological model is used for the knowledge based system for the analysis of defect elements in a building structure.

The knowledge case base consists of 3 ontologies that are interrelated with each other. These ontologies are:

- Defect-ontology, describing different classes and types of defects and classifying them according to building elements hierarchy;
- Cause-Ontology describing different causes of defects;
- Treatment-ontology describing different treatments.

The prototype is developed with the help of the Jena Framework (Open Source Semantic Web Framework for Java). It provides a programmatic environment for ontologies and allows to integrate the knowledge case base with other system. The models are queried through SPARQL query language.

A Knowledge-Based Library of Building Element Templates for Fast Approximate Detailing

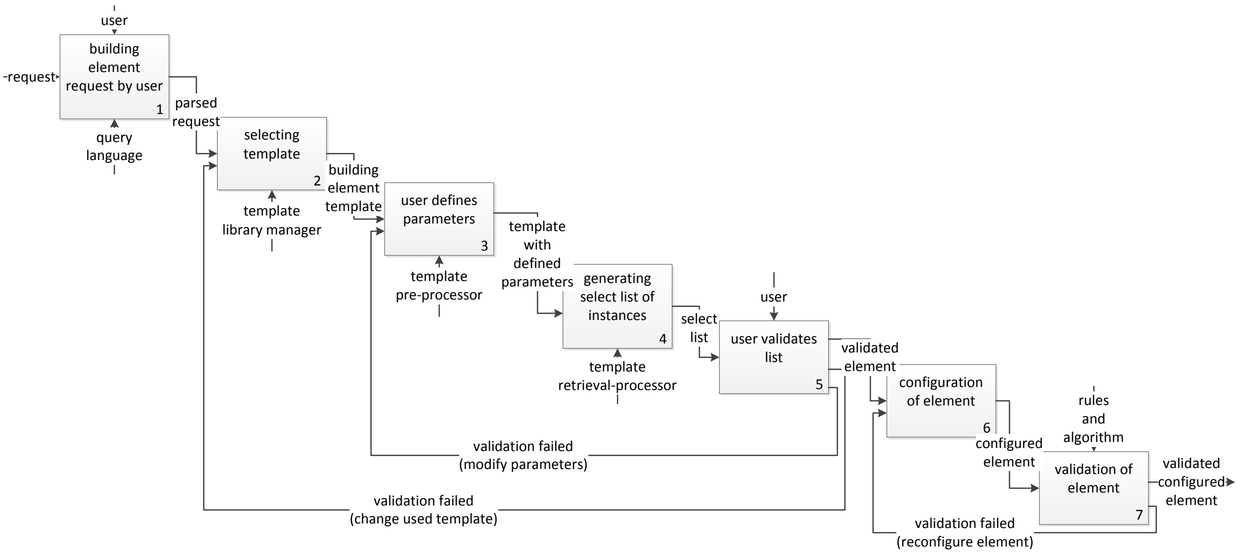
Frank Opitz

Objectives

Simulations of energy interrelations in complex or even in simple construction projects require massive detailed data and information about the structure of the building, materials and their physical properties, geometric granularity of the building elements, adjustment and location of the building, the clime at the site and the occupancy of the rooms. Besides these main characteristics, further various side characteristics exist which influence the simulation to a lesser extent, for example window and shade operations.

Today there already exist databases for climate information, material descriptions and definitions, topological and geological maps to locate buildings and pre-defined occupancy profiles. However a standardized and fully circumscribed database or library of building elements, in particular for fast detailing, e.g. for thermal simulation studies in the early design phases is missing. Existing databases of building elements are often limited to an array of products of only one producer.

Another fact is that e.g. energy simulation specified data is not part of a standardized building model. To execute energy calculation before the construction phase starts such necessary data has to be collected in mostly time-consuming way.



Basic workflow to generate an instance of a building element template

Approach

Starting with a user request the aim is to retrieve and generate a building element or a variation of elements and to integrate these elements in an existing building model with a given data format. The request must be based on a defined query language e.g. the M2A2 (Multi-Model Assembly and Analyzing Platform) query language. Using the parsed request the template library manager selects templates from the template store. The template-store consists of a database to save generalized templates and an ontology to define relationships between the templates and create a knowledge-based information space. Every template has various parameters. Each parameter must be defined by the user by assigning either a constant value, an interval range or using a stochastic approach choosing a value with a margin of deviation. After the parameter assignment the template retrieval-processor generates a list of selected and instantiated building element template. Next step is to validate the generated list of elements by the user and selecting one or more elements or even a set of variants if a variation or sensitivity study is requested. If the validation fails two options are possible. First one is to modify the parameter of the template by the user; second one is to choose another template by the template library manager. After passing the validation the element has to be configured to adapt to the current model context in particular to the neighborhood elements. To validate the data integrity of the configured element various rules and algorithm are used. A negative result of the validation leads to a reconfiguration of the element. If the validation succeeded the building element is ready to be integrated in the building model. This research work is part of the projects ISES and eeEmbedded.

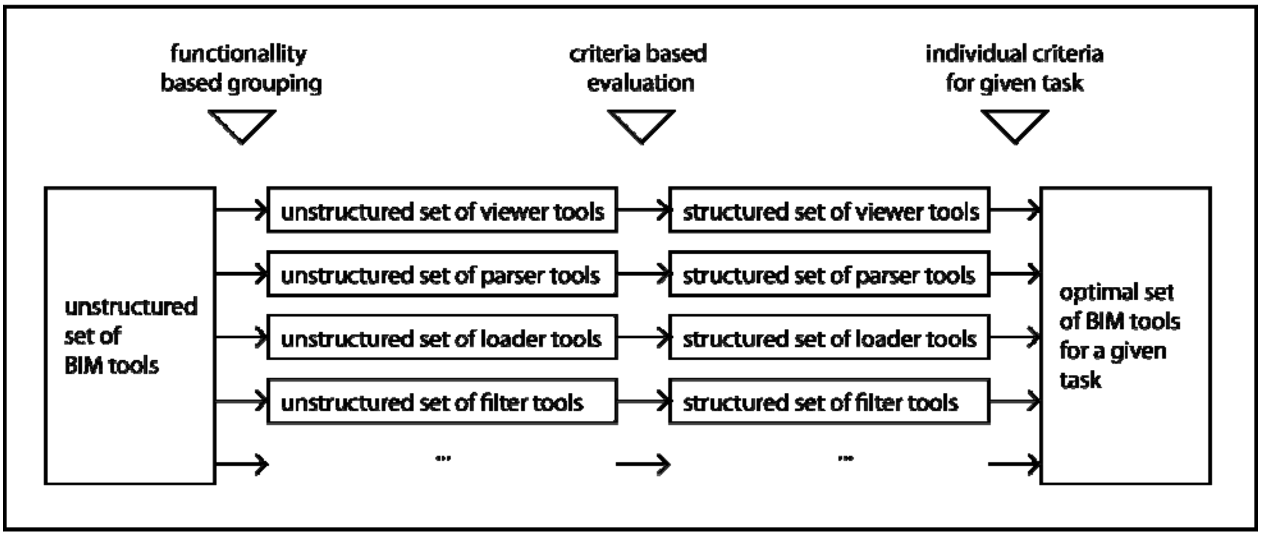
Development of a Knowledge Base for BIM Core Tools

Mario Gürtler, Marc Mosch

Objectives

In "Assessment and continuous updates of end user requirements", Gehre et al. remarked the lacking of a coherent methodology and the poor supported by CASE tools for the early phases of ICT development in the AEC industry [Gehre et al. 2003]. Since then, a lot of BIM-IFC services arose. But still an open BIM framework with a general use Internet platform is missing. In the course of many innovative projects the BIM community developed and continually refined a highly extensible BIM framework. It includes a lot of functionality based on the BIM concept and additionally enables the integration of external BIM tools. The framework allows to create software which covers the most needed and used BIM functionality.

Currently a wide variety of BIM tools exists. Many of them address similar issues in different ways, and with varying effectiveness. In order to optimize the further extension of the BIM framework and to support its ongoing development, it seems necessary to create an appropriate classification of existing BIM tools which can be integrated. The involved intensive survey and consolidation process, abstractly depicted in the following figure, will result in a guide for BIM developers. This guide should help to select the most suitable tool for a given task and precisely identify deficits and gaps of the existing tool park. Furthermore it will eliminate unawareness of suitable existing solutions, which is mandatory for developers striving to reuse existing code and even whole tools instead of reinventing them.



Workflow of the consolidation process for BIM tools

Approach

The survey begins with an intense research in order to extract those BIM tools from the large pool which provide an appropriate interface and can therefore be natively integrated into the framework. Based on their functionality, the selected BIM tools will then be analysed and subsumed. The resulting functional categorization can for example contain groups like viewer, parser, loader and filter. Afterwards indicators have to be specified which can then be used to evaluate and distinct the tools in each of the categories. There are common criteria which are relevant for all tools and criteria which are unique for each category. Common criteria are for example performance, quality of documentation and dependencies. In the case of a viewer, category-specific criteria might be model resolution, range of filters, query language, user interaction, functionality, intuitiveness or the ability to represent additional information like the model structure. The gained knowledge may finally be presented in form of a knowledgebase inside a Wiki. The overall result of this work will be a speed-up of the BIM related development process.

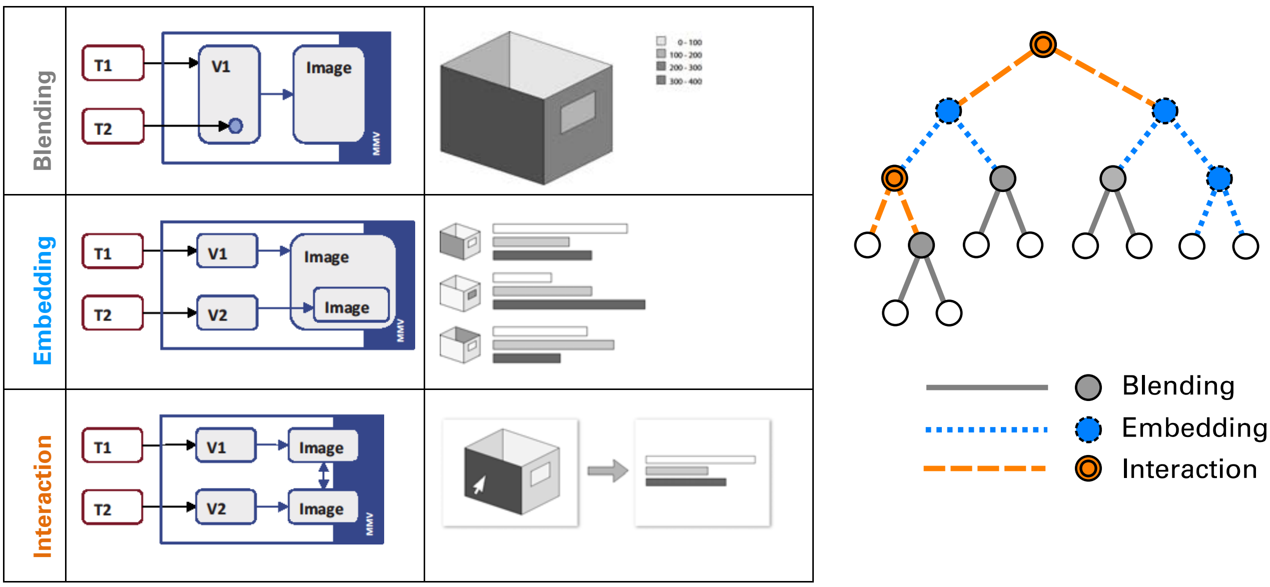
Specification of Complex Visualization Configurations Using Hierarchically Nested Mapping Rule Sets

Helga Tauscher

Objectives

With the ongoing development of Building Information Models (BIM) towards a comprehensive coverage of all building information in a semantically explicit way, visual representations became decoupled from the building information. While traditional construction drawings implicitly contained the representation besides the building information, nowadays they are generated on the fly. The idea of a generic visualization component aims at recoupling the building information and its visual representation.

Towards this goal a framework is developed, which can reproduce visual representations reliably given a visualization description together with the building information. In the process the visualization description serves as configuration information for the generic visualization component. The current implementation of the framework is already able to generate visualization models from domain models using simple mapping rules. As the amount of explicitly modeled information is constantly growing, sophisticated and complex visualization methods are needed. The visualization description and the framework should support arbitrary complex visualization setups.



Modes of visualization construction (left) and their hierarchical application (right)

Approach

The proposed method allows for obtaining complex configurations from simple base configurations.

Breaking down the complexity into manageable units is possible using three different modes to distribute information in the visualization space: Blending, Embedding and Interaction (Figure, left part). Blending represents information in a limited area at a specific point in time, Embedding distributes information in space and Interaction changes the representation according to user input or an animation schedule. A visual representation is then constructed by recursively applying these modes to chunks of information, thus nesting visual representation parts and creating a hierarchical structure (Figure, right part). Organizing complex issues in a hierarchical way facilitates understanding and is the natural way for the human mind to get the issue under control.

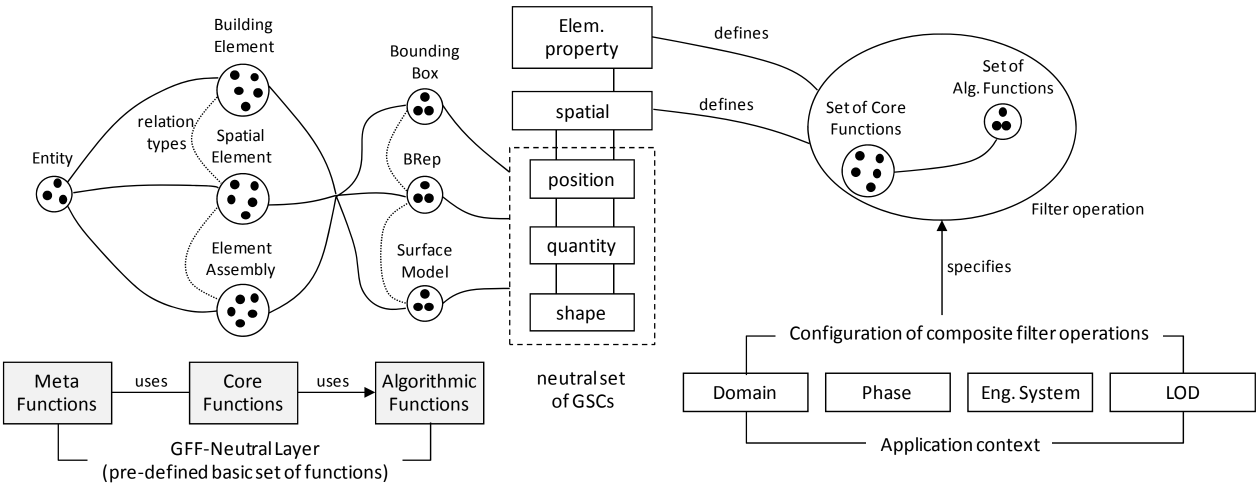
The framework will handle these different modes of visualization construction as well as their nested application. Thus, users of the framework are encouraged to organize their visualization descriptions in a hierarchical way. An analytical step preparing the following implementation has to answer questions like: How are the three modes associated with the mapping rule system? Which kind of relationship exists between the information underlying subsequently nested visualization parts? How can the association between original information and the visualization model be retained across nested parts? The prototypical implementation is finally evaluated using multi model data from a realistic project.

Geometrical and Spatial Constraints in BIM-based Information Filtering

Ronny Windisch

Objectives

It is obvious that geometrical and spatial information about abstract and physical building elements as well as the building itself in various application contexts plays an important role in all phases of the building lifecycle, e.g. for design validation like clash-detection or code-checking, automated information pre-processing for downstream applications like computational structural analysis, quantity take-off or construction resource planning. Thus, in the frames of a BIM-based project environment, information filtering comprises various use cases applying geometrical and spatial constraints (GSC) in order to enable seamless information exchange and delivery thereby providing application and task specific information subsets derived from a commonly shared project information space, e.g. represented by a building information model. Information filtering processes like ad-hoc model querying or static and dynamic model view generation may apply GSCs in terms of predicates or information requirements represented by derived, calculated or aggregated object sets or values according to user-defined element types, properties or geometrical and spatial relations between different elements with respect to the given application context at hand. Since the application context specifies the information needs of a particular actor and may vary regarding engineering domain and system, project phase and level of development (LOD) numerous types of GSCs, i.e. types of geometrical and spatial representations of building elements, their parts and relationships, have to be supported based on a commonly used, neutral data model (e.g. IFC). The outlined research work aims to develop a geometrical information filtering framework that provides for the application of GSCs in various use cases with respect to the variety of the actors information needs occurring in BIM-based information management processes.



Composition of geometrical-spatial-constraints based on a generic filter framework

Approach

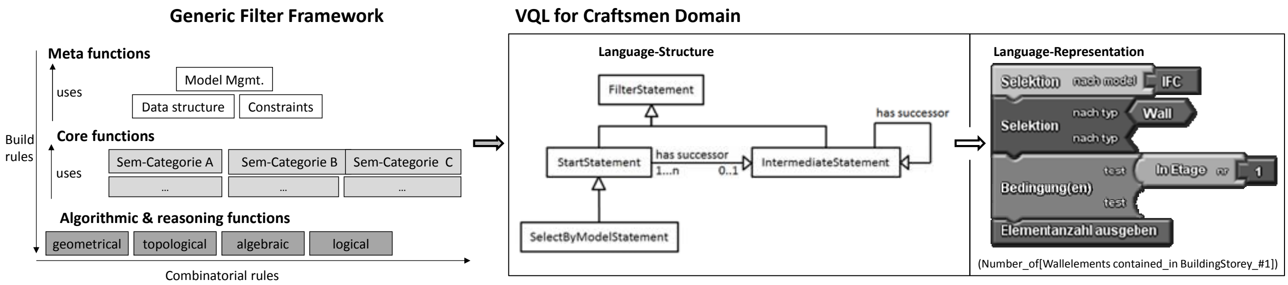
The capabilities for applying geometrical and spatial constraints in information filtering processes shall be embedded into the Generic Filter Framework (GFF) recently developed at our Institute. The GFF concept is based on a breakdown of single application specific filter operations into several reusable and configurable filter functions encapsulating a particular piece of operational logic. Each filter function is assigned to one of three different levels of abstraction which together establish the Neutral Layer of the GFF. Each layer implements the operational mapping to the concepts of the upper layer since each function is specified by using functions of the layers below. This approach allows for providing filter functionality tailored for a considerable amount of different application contexts based on a finite set of pre-defined filter functions. However, the amount of relevant, domain-independent geometrical information considered in the approach can be divided into three main categories: (1) quantity, (2) shape and (3) position, and two sub-categories related to the geometric reference for each of them: (a) self-referred (element properties) or (b) relative (to other elements or a certain spatial reference). The GFF will be extended to integrate the according stringent geometrical concepts with information derived from engineering knowledge in order to define GSCs related to a particular application context.

A Domain-specific BIM Visual Query Language

Alexander Wülfing

Objectives

Effective and encompassing access to a particular information needed for a certain work task in a specific domain is a major prerequisite for efficient BIM-based collaboration due to the comprehensive information contained in complex project models. Therefore appropriate, easy and intuitive to use filter and query methods are required that match the specific needs of the various actors in the different expert domains involved in the overall building lifecycle. In particular an appropriate filter and query method has to enable a separation between the model semantics defined by the underlying data model and the semantics of the domain specific concepts used in a certain expert domain. This separation will enable the usage of well known domain specific concepts for the formulation of query expressions without the need for learning the schema specification of the underlying data models and costly programming of model evaluation and analyzing algorithms tailored for a specific domain. Important domains for the need of flexible and efficient extraction of task specific information are e.g. those represented by the craftsmen. The model querying should be done in an easy and trade specific way, not burden craftsmen with learning some kind of programming languages like Java or text-based query languages to formulate model queries. A visual query language which uses well-known concepts of the craftsmen application domain should disburden the craftsmen and gives him an instrument for the effective use of BIM models in its daily work. Additionally, an easy to use but powerful query language that is optimized for the needs of the craftsmen domain will lower the threshold and effort required for the adoption of the BIM-based work paradigm by the small and medium crafts enterprises which represent a major part of the construction sector.



BIM Visual Query Language (BIMvql) based on a generic filter framework

Approach

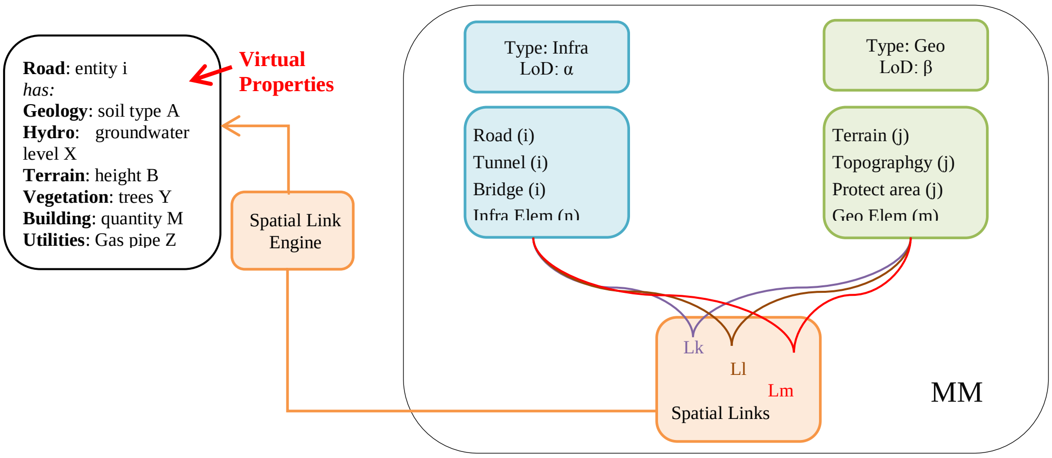
Based on the Generic Filter Framework (GFF) and its Java-based implementation, the multi-model filter toolbox BIMfit, a BIM Visual Query Language for craftsmen (BIMvql) will be developed. The GFF offers a basic set of modular, domain and application independent filter functions that can be flexibly combined to filter operations of any needed complexity and assigned to various domain specific concepts. A combination of one or many filter operations represents a single model query. Based on the GFF and the context dependent combination of the base functions various domain specific query languages can be defined due to its generic definition. The BIMvql will be the first query language based on the GFF and will be also used to analyze and explore the development of GFF derived query languages. However, in a first step the elements which are needed for such a BIMvql in general and the elements which are needed to fulfill the domain-specific needs of craftsmen will be identified. This includes required constraints and relations of the language elements. Furthermore the logical structure of the language (abstract syntax) as well as the semantic and the graphical representation (concrete syntax) of the language will be elaborated (Fig. 1). After that it must be examined how the filter concepts of the BIMvql can be represented by filter functions and filter operations of the GFF. The evaluation and interpretation of BIMvql query statements will be based on a formal language structure. BIMfit is used to execute the BIMvql queries and to produce the query result.

Interoperability of Infrastructure Planning and Geo-Information Systems

Nazereh Nejatbakhsh Esfahani

Objectives

Building Information Modelling or Model-Based Design facilitates to investigate multiple solutions in the infrastructure planning process early enough to help better decision making. The most important reason for implementing model-based design is to help designers and to increase communication between different design parties. It improves team collaboration and facilitates faster and lossless project data exchange and management across extended teams and external partners in project lifecycle. High level infrastructure suits mostly facilitate to analyze the infrastructure design based on the international or user defined standards. Called rule-based design, this minimizes errors, reduces costly design conflicts, increases time savings and provides consistent project quality. Yet design packages either don't consider GIS domains such as energy and environmental impacts or consider their own data domains like materials and land which might not meet the requirement of the other project members. Besides infrastructure projects demand a lot of decision makings in governmental as well as Private Public Partnership (PPP) level considering different data models. Therefore lossless flow of project data as well as regulations across project team, stakeholders, and governmental and PPP is highly important. Therefore because of the lack of or poor integration between different data models involved in infrastructure projects, a new method of BIM for infrastructure projects has been investigated.



Spatial Links of Infrastructure and Geospatial Data Models and obtaining Virtual Properties in an MM

Approach

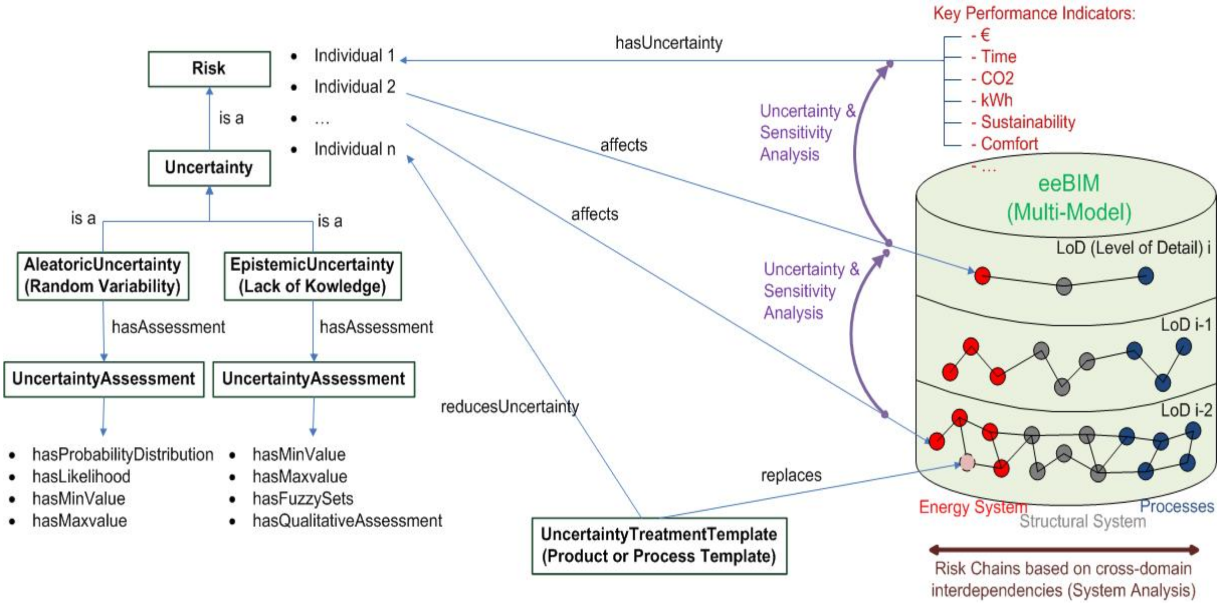
Multi Model (MM) is a method where heterogeneous data models from various domains are bundled together into a container keeping their original format. In separate Link Models the elements of the data models will be linked together. Yet the multi model and the generated links have no inherent domain semantic. In infrastructure information processes, there is a need for semantic linking of different data models, because it is not known which domain models might be integrated in future tasks. Therefore a method is needed which allows for definition of semantic links or an adequate rule based filtering through topological queries. The most important unification of data models involved in infrastructure projects is the spatial property of them. Spatial identification joins such data models in a semantic way. Therefore the promising approach for the interoperation of Infrastructure and Geospatial Domains is to generate interlinks through spatial identity of entities. Called Spatial Links, these match the geometry of infrastructure data with the geospatial information in accordance to the location of the elements. Each infrastructure entity receives the spatial information which is stored at the location of entity or is related to the targeted entity due to sharing the equivalent spatial index. Thus, the geometrical entity which is devoid of spatial intelligence gets through this approach all information related to the entity. This information will be virtual properties for the object. Nearest Neighborhood algorithms are applied for spatial match finding and a filtering and refining approach is performed in accordance to the LoD and product model being observed.

Capturing Uncertainties in BIM

Hervé Pruvost

Objectives

Risk, also defined as uncertainty by the international standard ISO 31000, is common in all phases of the building life cycle and is most of time ignored. It can be of two natures, the aleatoric and the epistemic uncertainty. The aleatoric uncertainty defines probabilistic events or value variations that exist because of the stochastic nature of a project or a system. The epistemic uncertainty defines rather ambiguities or lacks of information by which no randomness is associated. As the experience shows uncertainty is associated with increased resource usage. Indeed, typical uncertainties cause exceeded costs or delays if they are not treated, and imply investments or allocation of new resources to be prevented. A similar observation is that uncertainty demands efforts in planning flexible products and processes that can deal with their uncertain issues. For example having no historical climate data to use for energy consumption calculation demands to take into account extreme temperature values and thus to oversize the energy system. Or not knowing the future changes in the building utilization need to plan equipment reserves. The uncertainties have direct influence on the KPI (Key Performance Indicators) of the project. That's why it is of importance that the ICT system is able to capture them.



Consideration of risk in an integrated BIM Framework

Approach

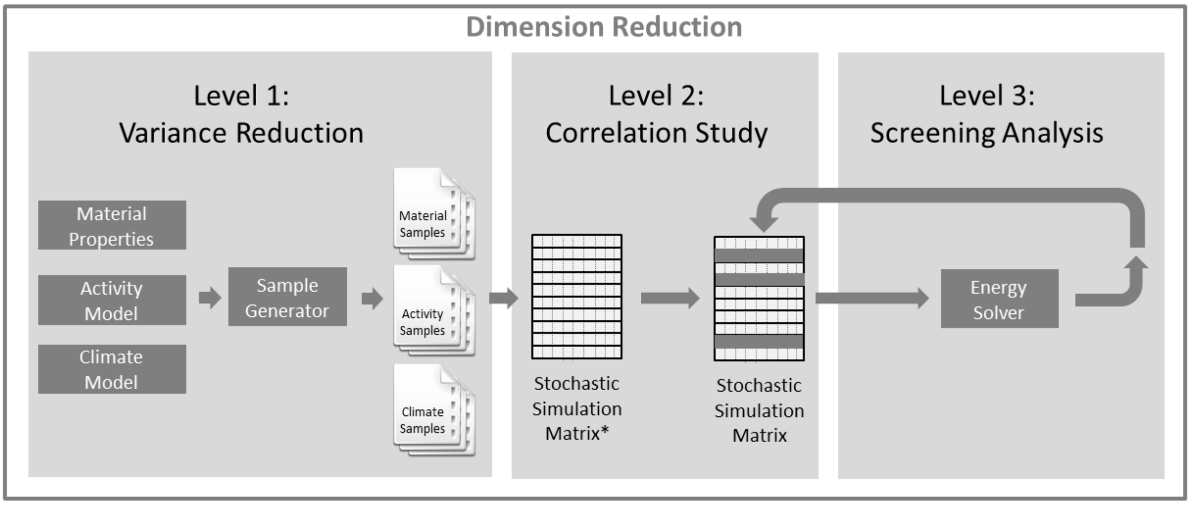
We decided to develop an ontology in which the concepts around uncertainty are modeled in a taxonomy. This uncertainty model can be then interlinked with BIM or with other models applying the Multi-Model method. In this way uncertainties can be easily allocated to project objects in a domain independent manner. Indeed a common problem resides in the fact that uncertainty is often described directly in application models based on existing standards like XML or IFC using quantitative value attributes (minimal, maximal, mean, variance, etc.) of different data types. As a consequence uncertainties are quite difficult to filter and extract through queries as they are modeled as attributes of too many different kinds. Along with capturing uncertainty in a generic manner the use of ontology enables to perform logical reasoning on the integrated uncertain BIM. Risk chains can be (1) described vertically thanks to uncertainty and sensitivity analyses that assess the effect of uncertainties from the underlying domain models on KPIs and (2) inferred horizontally through causality relations and domain objects interdependencies. Moreover the instantiation of corrective product or process modifications can be inferred from a treatment templates ontology. This Ontology describes for every treatment template its corrective effect respectively its ability to reduce uncertainty and to maximize or minimize KPIs.

Configuration of Stochastic Simulation Matrix in Stochastic Extended Energy Model

Frank Noack, Amin Zahédi Khaménéh

Objectives

Stochastic Extended Energy Model (SEEM) is developed for the whole life-cycle of buildings and facilities to cover the uncertainty and variability of the involved parameters. The simulation task may require hundreds of individual simulation runs, performed in parallel, which should be managed and configured applying highly automated approach. The platform shall integrate several energy solvers. To provide stochastic capabilities, the stochastically sampled datasets need to be converted to a set of deterministic input files, which are called Stochastic Simulation Matrices (SSM). Just considering to reach the occurrence probability of 99.99 % of only one variable, 10,000 samples are required and every simple CFD (Computational Fluid Dynamics) simulation may take several hours. Hence, a holistic stochastic simulation, which comprises several stochastic variables, may be very expensive or at all not feasible if no dimension reduction is undertaken. Here, we are aiming to reduce the dimension of the SSM by a multi-level approach keeping the precision of the stochastic results.



The three levels dimension reduction approach of the Stochastic Simulation Matrix (SSM).

Approach

The SSM in the SEEM comprises the samples of the *material properties* which are linked to the building elements, *activity profiles* which are linked to the space zones and the *climate time-series* which are link to the building or facades. This data can be presented in a form of simple stochastic variables, like material property or as stochastic process, like climatic time-series and activity profiles the later may be generated as a set of constrained stochastic time-series.

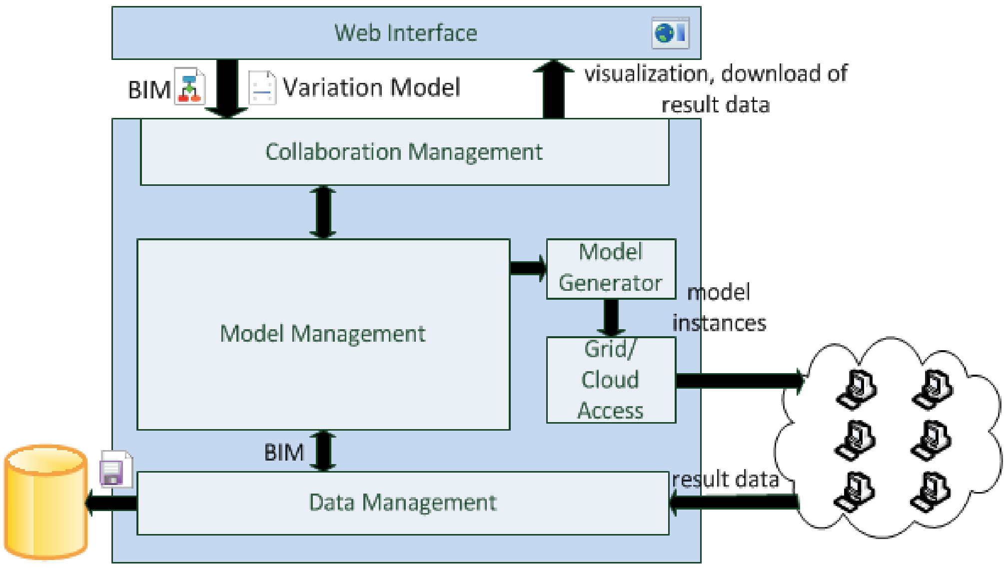
In order to reduce the dimension of the SSM, a multi-level approach is followed (depicted in the figure); 1) At the first level applying the variance reduction methods like Latin Hypercube Sampling (LHS) the input distribution through sampling in less iteration will be accurately recreated. 2) During the second level of the dimension reduction the correlation between the stochastic properties will be studied. It should be determined which properties vary together and which are vary individually. The properties variations which are not occurring together will be eliminated from the SSM. 3) The final level is dedicated to the sensitivity/screening analysis, which aims to describe how much model output values are affected by changes in model input values. Regarding these analysis the less important input variables are recognized and will be considered deterministic. Applying the suggested dimension reduction levels it is expected to be able to limit the number of simulations by about 2 levels of magnitude.

A Grid-/Cloud-based SOA for Parallel Simulation of BIM-based Civil Engineering Models

Michael Polter

Objectives

New design paradigms and safety and quality standards require the broad application of non-linear mechanical modeling and probabilistic safety concepts, e.g. in the design of bearing structures or interrelated energy systems. In civil engineering Building Information Models (BIM) include many variable parameters such as loads, soil and material properties but also model structure variations. The identification of appropriate parameter values often has to be done in a full probabilistic approach where the multitudes of parameter combinations require many separate non-linear analyses. For civil engineers and their calculation software this is a big challenge which reaches from the management of a huge amount of complex data to the generation, computation and evaluation of thousands of models. Our goal is to develop a flexible software platform based on grid-/cloud-computing to provide SMEs with the computing power they need to handle these complex tasks. Furthermore we work on the abstraction of model variation to automate the generation of model candidates for structural analyses and FE-computations.



Conceptual architecture of a web-based platform with grid-/cloud-access for generation and trivial parallel computation of huge model multitudes

Approach

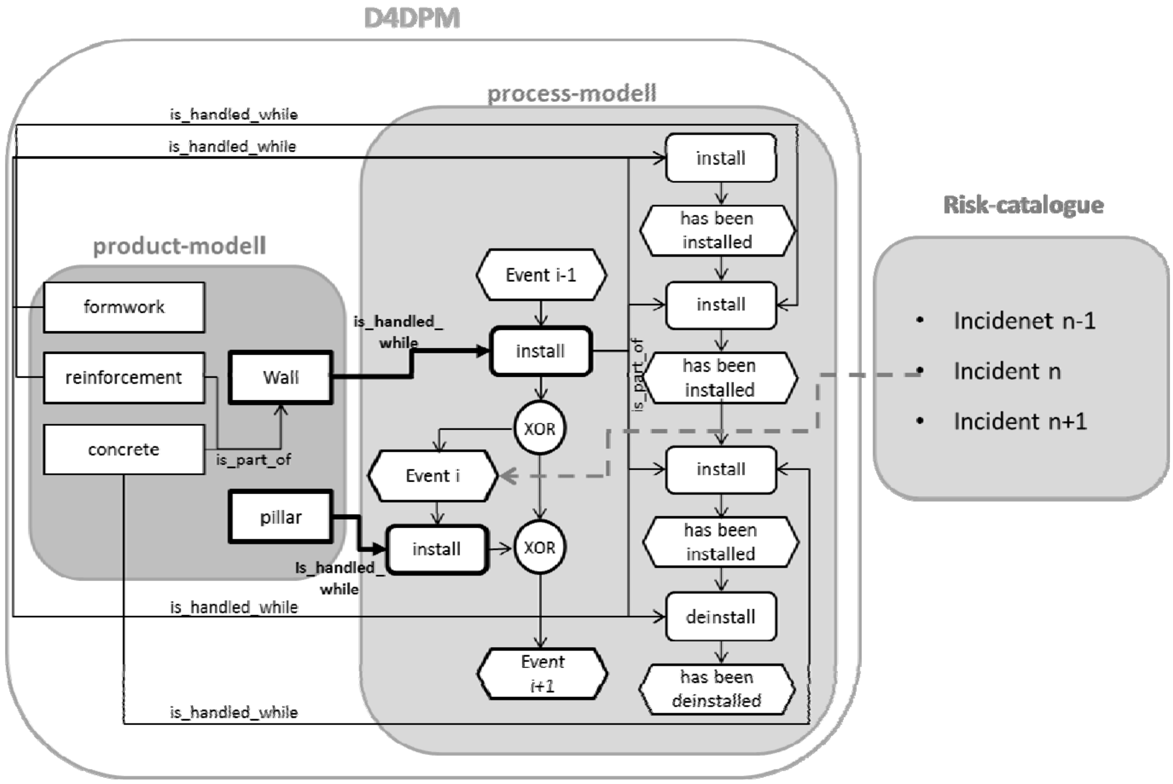
In order to handle the lack of computing power for complex simulation tasks in SMEs we develop a flexible, SOA-based web platform which is able to combine the desktop PCs (also from different domiciles) of a company to a private grid and thus provides the computing capacity to solve multitudes of models in a trivial parallel manner. The fundamental grid infrastructure, which was developed in the project GeoTechControl, will be extended to provide grid access to computation software for nearly every problem that can be scheduled in parallel and according to requirements include services of a public cloud if necessary. To disburden the engineer we also research for automating the generation of model variants. For this purpose we work on the identification of variation possibilities in BIM and abstract them into a distinct so called variation-model which is linked to the BIM. The application of data reduction methods and efficient storing mechanisms will help us to manage the huge amount of computed data.

Specialization of the Dynamic 4D Product-Model for Risk Response

Robert Kreil

Objectives

The construction phase of building structures is characterized by a large amount of different processes and crafts. Each single process can be affected by a large number of risks and unforeseen incidents. These events depend on the related crafts. Also there are diverse techniques for each craft that can be used during a process. Additionally there is a large catalogue of actions that can be used to prevent risks or that can be used to react to a risk after it has occurred. The quantity of these actions is approximately the product of the number of construction processes, crafts and risks events. Furthermore there is an effect on the subsequent processes if any incidents occur or actions are performed that shall prevent risks or minimize their effects. Even if the building-owner changes parts of the construction in some processes or the processes itself, big influences on following processes can occur. This arises the request of simulation in order to study at forehand how the whole process chain is affected by changes or unforeseen incidents. Therefor the assignment of the best reaction to a risk event is a very complex task that should be supported by ICT systems.



Part of a Dynamic 4D Product-Model with an incident changing the process chain

Approach

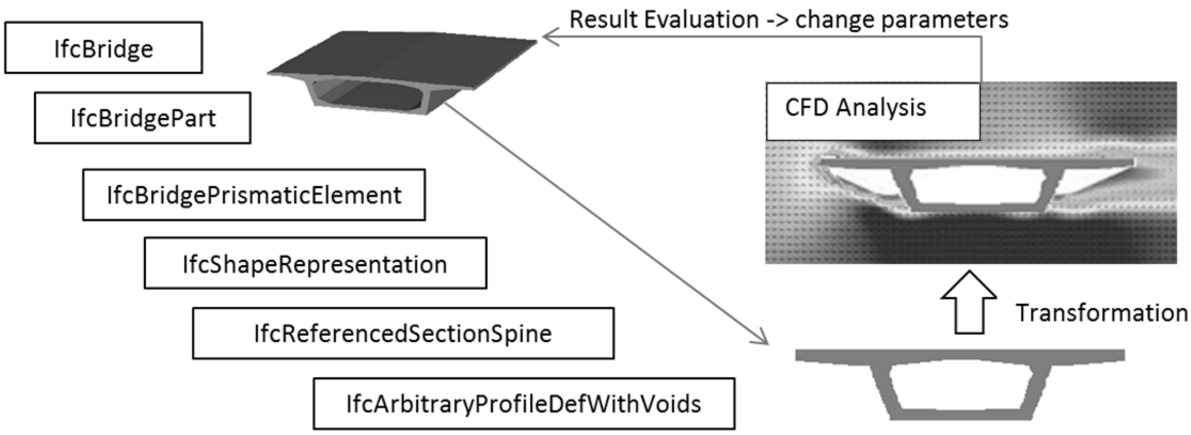
The propagation network arisen in this problem can be best described by the Dynamic 4D Product-Model (D4DPM) recently developed at the institute which describes beside the different products like a wall and the different construction process also the relation between products, between tasks and between products and processes by dividing the model in an interrelated product and a process part. These relations can be used to show the effects a single change or occurring risk can have on the whole process chain. For that purpose reasoners can be applied that can automatically find new relations based on pre-described semantic rules. For the generation of such D4DPM a simplified ontology editors has to be developed, which can easily be operated by engineers with less knowledge in ICT. Also D4DPM can be the basis for a template database that can be consulted for further building structures to improve the decision safety. The D4DPM should be combined with the configurator developed in Mefisto for the generation of process simulation models in order to easily be run at the end users' risk response simulation studies.

Developing an IFC-Bridge extension with special attention for structure-wind interaction analysis

Ali Ismail

Objectives

The Building Information Modeling (BIM) approach has established itself well for data exchange and collaboration within the building design process. However, the use of BIM standards like Industry Foundation Classes (IFC) is still limited concerning infrastructure facilities, such as roads, tunnels and bridges. The lack of support in the IFC data model and hence the implementation within common commercial BIM authoring software leads to an interoperability problems among stakeholders and their tools. This research aims to investigate and develop the necessary extensions to IFC specifications for the activity of bridge design especially in the early design stage and the data exchange integration for computational fluid dynamic (CFD) and fluid-structure interaction (FSI) analysis. The result of this research will enhance the design process and reduce the time/efforts needed for the manual data exchange for downstream bridge design processes.



One of the IFC schema extensions for bridges

Approach

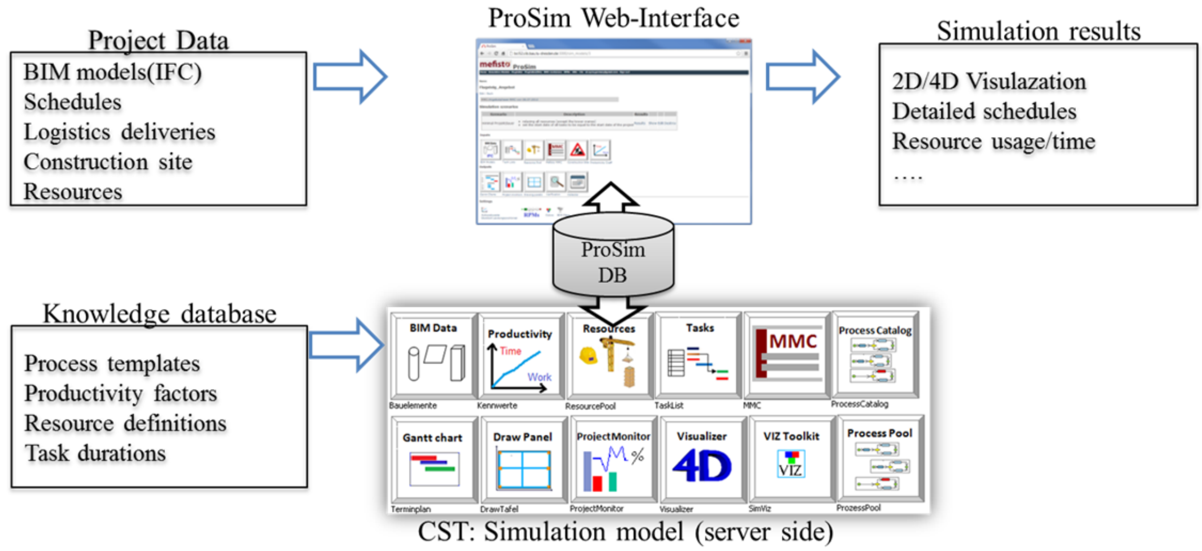
A full-parameterized schema combined with predefined design constraints and transformation rules will be developed in order to allow the designer to optimize the shape and topology of the bridge through a well-coupled design-analysis cycle. The research will particularly focus on the further development of the IFC-Bridge extension, which aims at standardizing definitions of bridge components and their geometric and semantic description as well as the hierarchical relationships and the integration with the PA-1 Parametric IFC schema, which allows any aspect of an IFC model to be driven parametrically. Providing a parametric geometric description enables a fast and automatic update and consequently speeds up variation studies, which are very important aspect for advanced applications in the bridge design process like structural and FSI analysis. The IFC EXPRESS schema will be extended to full fit the definition of information requirements for structure-wind analysis. The further development of IFC Bridge schema aims at: (1) Supporting different level of details for the geometry representations, (2) Parametric 3D product modeling (cross section, bridge elements) combined with constraint design definition, (3) Automatic transformation of IFC models to CFD models. Beside the IFC schema extension a prototype system for a rapid generation and visualization of bridge models based on the new extension will be implemented. The elaboration of this approach is part of the research work in the European project BridgeCloud.

Collaborative construction project planning using a cloud-based online simulation environment

Ali Ismail

Objectives

The use of simulation techniques to support traditional planning methods for project scheduling and optimize resource allocation is a very promising but also a challenging field of research. The process of creating a reliable and reusable simulation models is very complex, combined with high costs of software licenses and personal training for in-house simulation, or mostly with misleading or difficult to interpret results in case of using external simulation service with limited experiences in AEC domain. This ongoing research targets some of these obstacles by providing a low-barrier online collaborative simulation framework. The objectives of current research are (1) Extending the under development Construction Simulation Toolkit (CST) desktop platform with additional tools and data management layers to make it ready to run on cloud as online service (2) Adding a web-based communication and collaborative functions for active participation of involved planning, simulation and decision making actors.



Approach

CST[1] is a process-based discrete event simulation toolkit built on top of Plant Simulation by Siemens PLM to support planning of construction projects. It has been under continues development since 2010. The increasing size and complexity of simulation projects, especially in the construction phase, the huge amount of involved data and the need for high computing power to run simulations faster are the reasons behind moving CST from desktop to cloud software architecture. Available network interfaces beside the database connectivity make it possible to build an integrated data management around the simulation core components and offer it as software as a service (SaaS). As a result the simulation models will be available und re-runnable anywhere, responsive to any input update, and the visibility of all input and configuration data helps to identify errors and leads at the end to a better understanding among the planning and simulation teams. The web interface is going to provide the following features: (1) Online editing of simulation inputs and viewing of results, (2) Simulation scenario manager to edit/define new experiments, (3) Central and project specific process template repositories, (4) Knowledge data management of productivity factors, resource definitions, and task duration of standard construction tasks, (5) user roles and permission management.

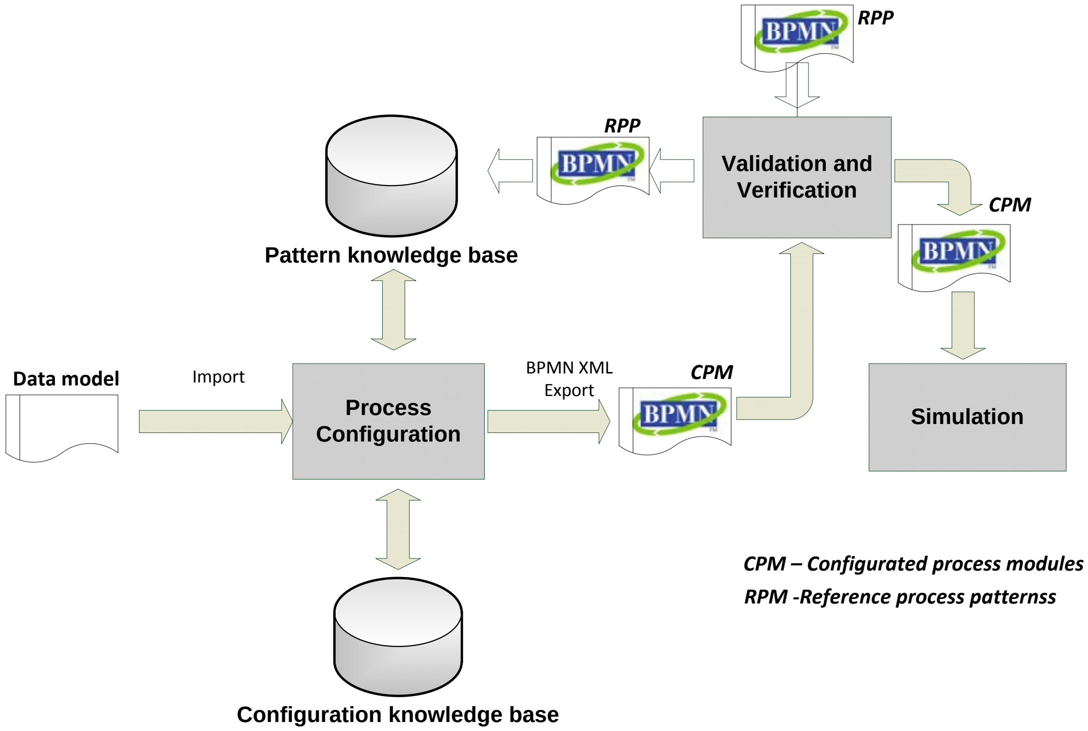
[1] http://bci52.cib.bau.tu-dresden.de:3000

A Generalized Methodology for Process Modelling and Configuration

Alexander Benevolenskiy

Objectives

The approach proposed recently in frames of the project Mefisto shows how the ontology-based model can be used for the modelling and configuration of construction processes. The introduced methodology demonstrated its power and suitability for the area of construction processes, where the structural concrete works are considered. Together with some positive results it also showed some limitations and "bottlenecks" of the implementation. In this work some of these limitations as well as proposals how to overcome them are considered. Moreover a complete new methodology for the general process configuration and modelling is shown. This methodology is based on the concepts and methods already successfully implemented and described in the previous work, but it is modelled to be more general and so applicable for different domains.



A general methodology for the process modelling and configuration

Approach

One of the main ideas of the proposed approach is to use a general and domain-independent structure for the process pattern. This general structure consisting of the few main components such as: *Process, Resource, Subprocesses with their order, Description, Meta data* is utilized for describing different types of processes and can be quickly adopted for various projects and domains. The patterns are formalized in the BPMN standard that has the advantage that patterns can be easily visualized with the help of many BPMN tools and exchanged between different systems.

The overall system consists of 3 main components that are interacting with each other:

- *Process configuration component* is used for the instantiation and configuration of the generalized process patterns;
- V*erification and Validation component* is used for verification and validation of the reference process patterns as well as configurated process modules with the help of the Petri nets;
- *Simulation component* is used for the simulation of configurated process modules with the help of the simulation software.

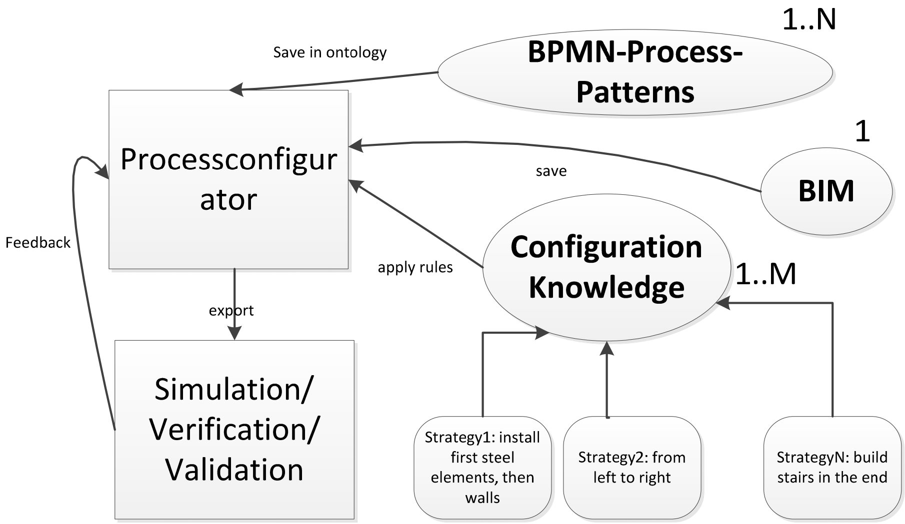
Furthermore two knowledge bases are used in the system. *Configuration knowledge base* is used to store configuration strategies and in the *Pattern knowledge base* process patterns are saved.

Process configuration in construction by means of ontologies and rules

Ksenia Roos, Alexander Benevolenskiy

Objectives

Construction industry can be characterized as a field with many unique building projects, many heterogeneous resources, geographically distributed construction and planning workers having different software and process planning applications. Moreover there exist only few construction standard models, like BIM, which are accepted by the construction community. And finally there are no standard formalised and widely accepted construction process models, which could be used as the base for a specific construction project. The aim of this work is not only to overcome the interoperability and collaboration problem in construction, but also to make the process planning comfortable, semi-automatic and observable for non-experts. This formalised process should consist of configurable pre-defined process patterns, which represent the best practices of the previous construction projects. Furthermore the configured process should represent the specific project-oriented knowledge and the dependencies between the construction activities. The work focuses preferably production process in the precast field. The output process should be verified, validated and simulated in a separate application, and therefore should have a standard exportable process format. Another important aspect of the research methodology is representation and using different kinds of knowledge on each stage of the process configuration, as well as strategic knowledge. The user should have a possibility to apply different construction strategies and investigate their impact on the construction process performance.



Principal procedure of the process configuration by means of ontologies and rules

Approach

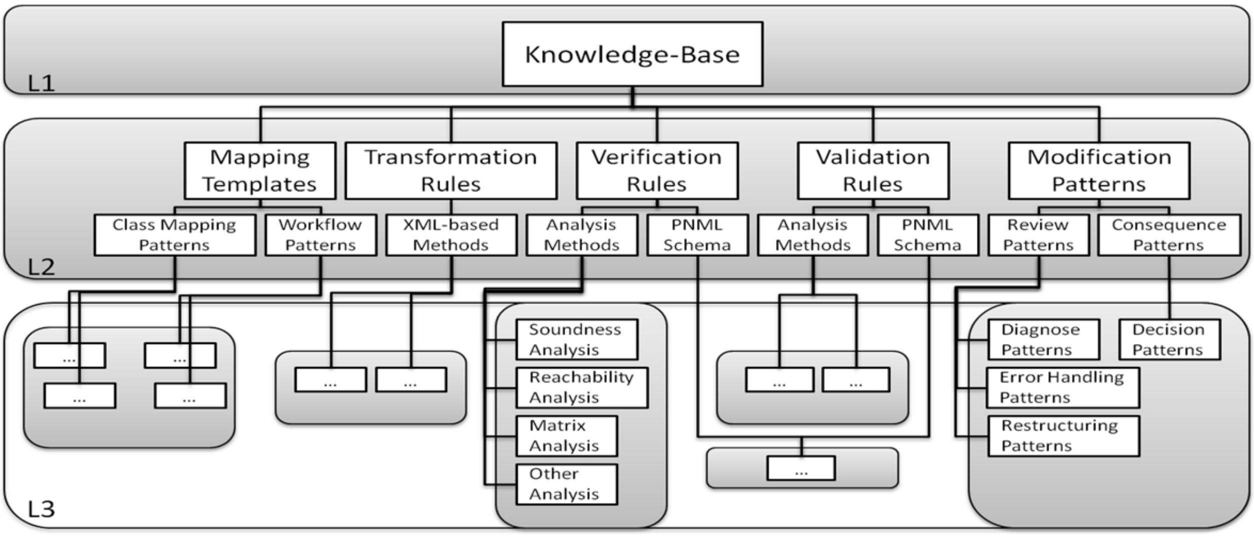
The process patterns are saved in the BPMN (Business Process Modeling Notation) format and can be automatically formalized by means of Description Logics and saved in the Process Pattern Ontology. At this stage the user defined application information should be saved, for example that a certain pattern can be used for the prefabricated wall erection. BIM-Model for a certain construction project will be partially translated in the Process Instance Ontology, the product concepts of the BIM-Model, like walls, slabs, etc. will be associated with the corresponding process concepts, like erect wall etc. On the configuration level the user defined specific information can be formalized with the help of the rules, for example such constraints like finishing all the formwork activities one day before weekend. And finally the strategic knowledge in a form of the rules will be formalized. During the configuration it is possible to apply multiple strategies, solving the conflicts between them with the help of the priority-property. In the Process Configurator, which consists of the ontologies together with the rules, the new knowledge about the final configured process will be inferred. This knowledge can be represented in the BPMN-format, which will later be processed by the verification, validation and simulation tools. After this procedure the feedback to the Process Configurator can be given, whether a certain strategy or user-defined constraints impacted a time- , cost- or resource-efficient construction process. Evaluating this parameter together with the strategies the best practice can be found without "practicing".

BPMN Represented Configured Construction Process Verification and Validation

Faikcan Koğ

Objectives

Process configuration is a smart method to integrate several business process variants into a single model, helps to omit unnecessary process parts and to give flexibility to the modeled business process. In the construction industry process configuration should support not only process sequence variants, but should also support ad hoc changes in the construction process at all stages. Moreover, construction projects consist of very complex and detailed processes, which are not easy to model or to integrate with each other. Therefore 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, infinite loops, logical errors, etc. and determines the model coherence according to the real world. In the construction practice it is not enough to model and simulate the construction projects because construction sector needs more sophisticated facilities to design and to control inherent uncertainties of their production systems due to one of kind product, production and project organization, due to the high complexity of the projects and due to the short lead time. The objectives of this research are (1) complementing the existing modeling methods and tools for verification of construction process models according to the behavioral and structural properties and (2) improving the verification and validation processes with modification patterns to diagnose and to restructure ill-behaved process models within knowledge-base.



Hierarchy of Knowledge-base for Process Verification and Validation with Templates, Rules and Patterns

Approach

The main focus of this research is creating a knowledge-base using templates, rules and patterns in order to verify, validate and modify configured process models. Petri Nets method is selected for the verification and validation purpose. Three main levels, which are L1, L2, L3, are defined for the knowledge-base. L1 indicates knowledge level and L2 indicates information level, which consists of mapping templates, transformation rules, verification rules, validation rules and modification patterns. Mapping templates and transformation rules have been already investigated. Therefore verification rules and modification patterns are the main research topic. Firstly, new analysis methods will be developed or existing methods will be adapted in order to improve verification rules. Some basic methods like soundness, reachability and incidence matrix are already defined. Secondly, process patterns, which provide common or general solutions for the complexity, will be adapted for the integration and simplification of the knowledge base as modification patterns. Modification patterns are defined in two main types, which are review and consequence patterns. Review patterns consist of diagnose patterns, error handling patterns and restructuring patterns. Consequence patterns consist of decision patterns. In case of an ill-behaved model, the designer can diagnose the problem, handle error and restructure the model according to his experiences or provided through a knowledge base. This indicates L3 the level of facts (cases) for modification patterns. The research will be further extended with validation rules too.

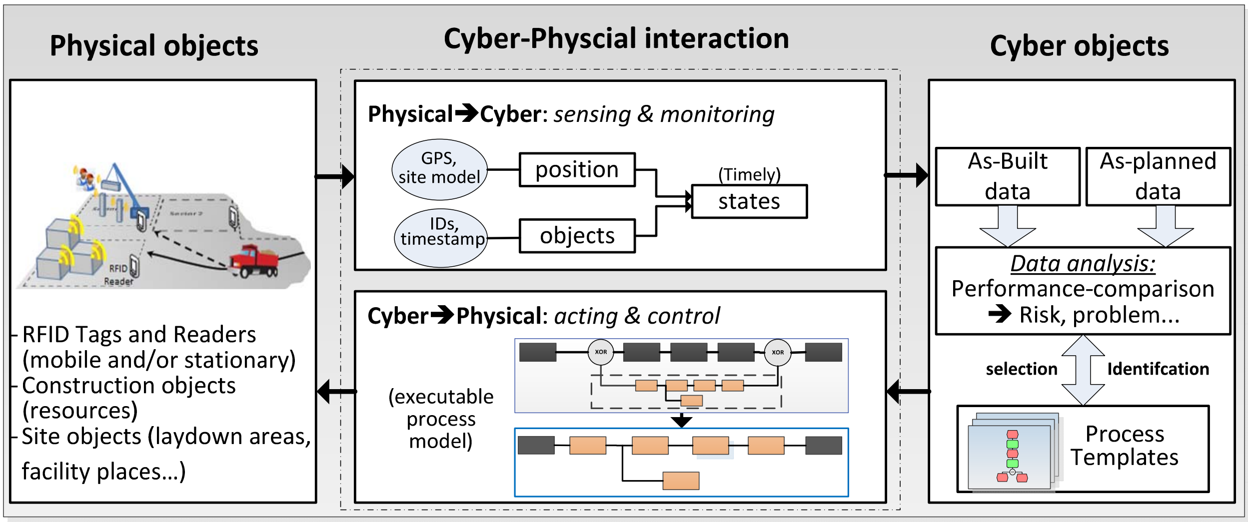
A CPS Approach for Construction Process Monitoring and Control

Yaseen Srewil

Objectives

The ability to effectively progress monitoring in real time can support construction project planning by early detecting schedule delays and making timely recommendations for corrective actions. However, this needs a close integration of the field where the physical objects are processed and their virtual models to enable data capturing on-site and a continuous comparison of actual with planned performance. The advances in ICT are opening the opportunities to achieve real time bi-directional coordination and integration between as-planned virtual models and the physical construction. This research is part of ongoing work that aims to develop a Cyber-Physical System (CPS) for the monitoring and control of construction processes.

The objective here is to enable an automated construction process monitoring in real time to detect the actual progress, identify and assess arising exceptions during construction phase like delays on time and planning timely recommendations for corrective actions in response to these adverse events. The CPS approach will simplify and possibly automate the process of monitoring and control during construction phase.



Cyber-physical system architecture; physical objects, physical to cyber sensing and monitoring, cyber objects and cyber to physical acting and control

Approach

To accomplish a robust construction process monitoring and control in real time a comprehensive loop solution is proposed. This solution comprises both the physical and cyber elements of CPS and the bidirectional interaction between them i.e. monitoring (from physical to cyber) and control (from cyber to physical). The starting point of this research work is reengineering of the physical construction site (site objects) to leverage collaborative data acquisition technology, which is mainly done by passive RFID elements. This allows a continuous monitoring of physical construction objects and minimizes manual data input leading to automation of data acquisition. From collected and validated data including sensor error detection interpolation of sensor gaps, the construction process progress can be derived and therefore as-built data extracted. Next, a continuous comparison between as-built and as-planned progress is executed to identify delays or exceptions during construction project execution. The analyzed real time monitoring data is integrated to control construction process using a suitable mechanism for change modeling. Here, the process templates are proposed as control tool by identifying and selecting an appropriate process fragment to respond to arising exception in process execution. Finally, the entire process model is updated and timely documented. This approach will enable improvements in progress monitoring, construction process control and documentation.

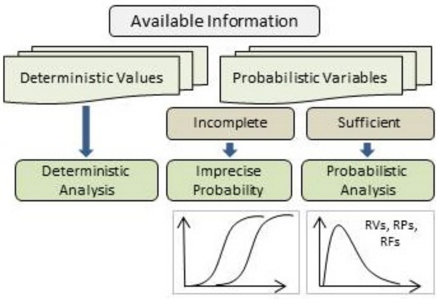
Complexity Reduction of Structural Systems

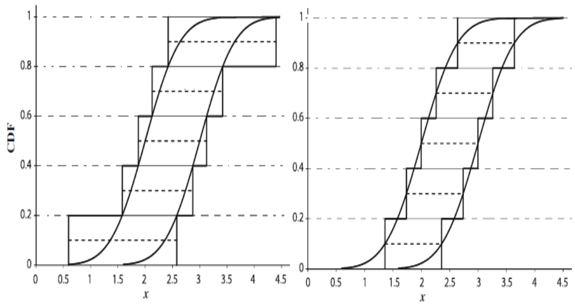
Jamshid Karami

Objectives

In recent years due to the need to more robust and efficient analytical tools to consider uncertainty and imprecision in parameters of structural systems the attention mainly has shifted from the deterministic methods toward probabilistic approaches. Probabilistic methods require appropriate mathematical modelling to obtain realistic results to predict the behaviour and reliability of structural systems. In practice the available data are often imprecise, insufficient and usually have poor quality they also involve sparse data, fluctuating and subjective information. This raises the question whether the available information is sufficient for probabilistic modelling or not. Thus it is a challenge to formulate suitable numerical models in a quantitative manner without ignoring significant information and without introducing unwarranted assumptions. If this balance is not achieved, computational results may deviate significantly from reality, and the associated decisions may lead to serious consequences.

The framework of imprecise probabilities provides a mathematical basis to deal with these problems which involve both probabilistic and non-probabilistic information. Imprecise probabilities include a large variety of specific theories and mathematical models associated with an entire class of measures. Probability bounds analysis is one of the new developed and efficient approaches to deal with imprecise information. In fact it is a numerical approach that allows the calculation of bounds when only bounds on the input distributions are known. These bounds are called probability or p-boxes. This concept permits analyst to make calculations without requiring overly precise assumptions about parameter values, dependence among variables, or distribution shapes.





Approach

Based on above discussion the main object of current study is developing an efficient dynamic FEM to deal with imprecision in input parameters of structural systems based on probability boxes in order to reduce the complexity as well as challenges in analysis of structural systems under dynamic loads. This study concentrates on development a new method to deal with uncertainty and imprecision in dynamic loads in structural systems based on imprecise probability approach and by means of dynamic finite element method. Uncertain properties and imprecision in dynamic loads are introduced based on p-boxes concept of imprecise probability. FE Analysis with p-box modelling of input parameters, including dynamic loads, estimates the range of the structural responses based on the bounds of the input parameters. It is crucial that obtained results be accurate and proposed method be computationally efficient. To reach these aims an efficient probability-box based Finite Element Method will be developed and then implemented.

At first it will be shown that, the p-box based concept is able to provide a frame work for handling incomplete input parameters of Finite Element model. Then it focuses on development a Finite Element structural analysis Method based on P-Boxes by establishment a new formulation of finite element equation with dynamic loads. The developed method should be capable to obtain the bounds of dynamic response of a structure based on defined bounds of input dynamic loads.

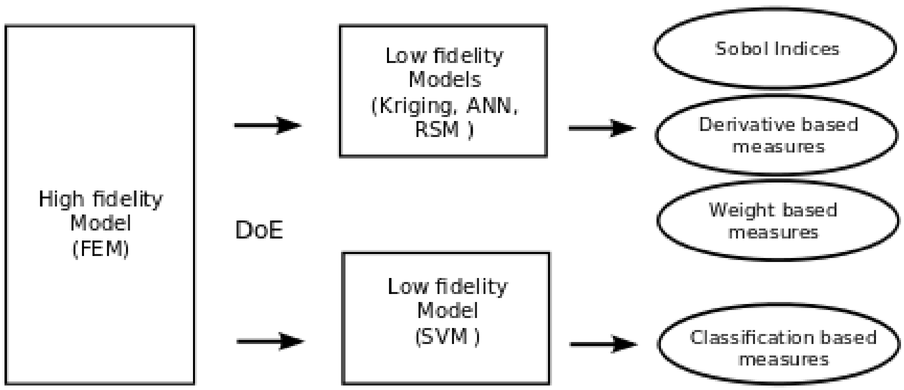
As the result of study the complexity of structural system, due to uncertainty and imprecision of dynamic loads, can be reduced significantly by new and efficient formulation of FE equation and loads vectors.

Efficient Methods for Global Sensitivity Analysis of Non-linear Models for Effective Optimization of Structures

Zeeshan Mehmood, Uwe Reuter

Objectives

An optimal design of structure requires a computationally expensive optimization process. The structural response is often dependent on a number of design parameters, so as the optimization process. The complexity of the optimization problem can be reduced if the relationship between the design parameters and the model response is effectively identified with the help of the methods of sensitivity analysis and only sensitive parameters are then considered for optimization process. Methods of Global Sensitivity Analysis (GSA) help in identifying the most significant model parameters affecting a specific model response. These methods are also applied by engineers for structural design problems for extracting the sensitivities of the structural response but these methods demonstrate certain limitations based on certain assumptions. Since the design of structures involves high-dimensional and computationally expensive physics based models, the classic methods of Global Sensitivity Analysis can only be applied using low-fidelity models because they require frequent calls to the underlying model of interest for their realization. For practical reasons, meta-models are then used with few sample points for calculating sensitivity measures. Thus, the accuracy of meta-models and the underlying theoretical basis of the classical GSA methods come into effect for problems related to structural design. The objective of this research is to evaluate and develop efficient methods for global sensitivity analysis of non-linear models in order to facilitate the optimization of a structural design.



Global Sensitivity Analyis using meta-models

Approach

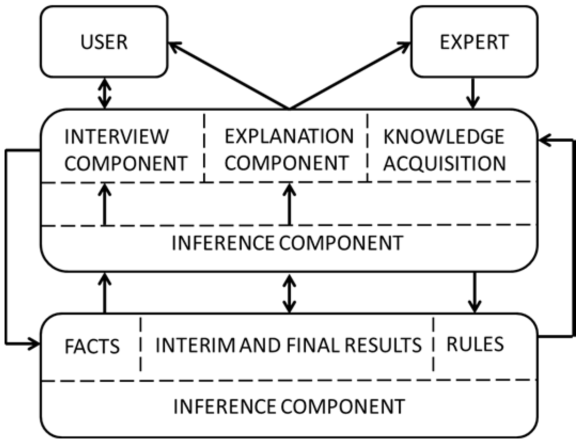
The practical implementation of already existing variance based, weight based and derivative based sensitivity measures requires meta-model based approximation of the structural response for the given structural data. These sophisticated sensitivity approaches provide results in a computationally expensive manner. In this research, the meta-model based approximation process is reduced to classification of the structural data at certain levels of the structural response and classification based sensitivity measures are sought. Thus, the requirements for a full approximation of the model response for calculating sensitivity measures are dealt with. The sensitivity is assessed by means of change in classification level in structural response. Classification based sensitivity analysis can be performed using Support Vector Machines (SVMs). Nonlinear SVMs perform classification by transforming the input space in a higher dimension space using kernel functions. In addition to change in class level, properties of the kernel functions and the discriminating hyperplanes in the higher dimension can also be exploited for calculating sensitivity information. Sensitivity analysis with classification models is likely to be less computationally expensive and can be easily applied to the relevant industry problems.

Development of a Practical Knowledge Base for Campus-Infrastructure Models

Eugenie Pflaum [1)]

Objectives

The aim of the research project is to enable the cooperative work with a central database and a central rule-based knowledge base to organize university typical informational processes more efficient and to provide a knowledge based system, which includes all important university building data in different places. It is centrally managed, updated for a long time period and integrated into any applications. The prototypical development of widespread knowledge base with references to normative standards and formalities for the campus-infrastructure-domain will be designed on the foundation of 3D-building models and data bases of the HTW Dresden. The implementation for several exemplary knowledge-based systems is related to it. Mechanisms of evaluation will be integrated to the final end-use and this makes it flexible to be realized in similar ways.



Basic structure of the knowledge based system

Approach

The knowledge-based system of the developing technology constitutes the core system. It uses knowledge of a knowledge base to involve data of a data base in application systems handled by users. In the same way, external data can be included via intelligent surfaces. The basic construction of the system according is shown in figure 1. From the user's point of view, he system is supposed to reach the level of an expert system.

To make the knowledge base manageable due to the complexity and scale of structure, elementary knowledge elements are represented as simply structured rule packages. A single rule is an implication in the sense of logic, which can be considered as a conclusion in the application domain.

A rule contains:

- a set of conditions that can be positive or negative (rule is applicable),
- an outcome which is applied after the fulfilment of all preconditions of the rule (rule is enabled)

This relationship can be represented as an „If – Then – Rule":

If condition_a, condition_b, … -> Then Action 1, Action 2, …

Rules, either on the left and on the right side can not only contain conjunctively linked sentences or sentence forms in the form of terms, but also disjunctions or negations. Terms can also be functions as procedural elements. This creates complex rules, but in smaller numbers.

In this way, knowledge can also be processed in small pieces, as many rules as for the current problem can be created. Each rule represents a small area of knowledge. Preliminary studies showed that this approach is both practicable and sufficient for the declarative as well as for the procedural formulation of knowledge elements as they are relevant to the field of campus infrastructure.

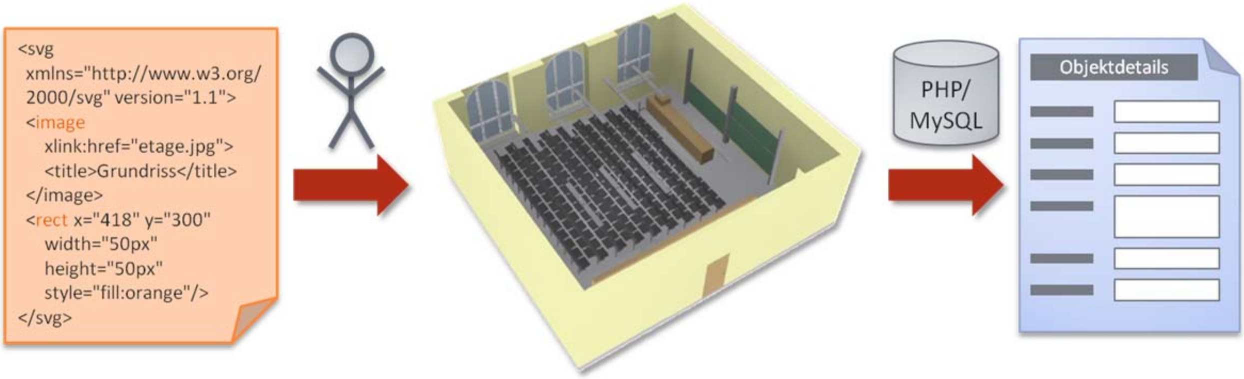
1) Co-operative PhD thesis with the University of Applied Sciences Dresden, supervised by Prof. Undine Kunze.

Interactive and Practical Web Application based on „3D-Campus"

Hermin Kantardshieffa, Peter Sobe[1]

Objectives

The infrastructure of an interactive and virtual 3D campus model consists of four component groups such as buildings (parts of a structure, floors, rooms), outdoor facilities like roads, squares and green areas, inventory (office and laboratory equipment) as well as technical building equipment like heating, plumbing, electrical installations, ventilation and air conditioning systems. In order to develop efficiently complex 3D campus models the data processing technology starts with 2D CAD drawings of floor plans and sections. Based on the data sources the 3D infrastructural models of the university buildings are created using CAD software tools AutoCAD, Allplan and Revit. Via the interfaces IFC and DXF a bidirectional data communication between the 3D modeling systems is entirely achieved. The further process according to the multi-level pipeline-like data manipulation technology includes the addition of a dynamic functionality to the static 3D objects. In this way a specific interaction with the user (e.g. clicking on objects, approaching certain areas within the buildings, etc.) is obtained. This is done in 3ds Max followed by the optimization process in Chisel for reducing the geometry by deleting redundant surfaces. As a result, interactive and highly detailed VRML models are produced. The goal of the proposed web application within the scope of a research project ISCID[2] is to present the detailed information that is provided by all kinds of infrastructural objects at the university.



Workflow of the technology for the web application „Object Details"

Approach

The web application „Object Details" provides detailed information about various infrastructural objects of the university on user request. The application includes the presentation of a SVG graphic and a three-dimensional VRML room model in the web browser. The object details are generated in the HTML format. The SVG file contains a link to the appropriate floor plan of a building as a monochrome 2D CAD drawing stored in an external data management system. It also contains the definition of graphic elements such as rectangles used for visual reference in order to achieve an interaction with the user. By selecting a specific rectangular area on the floor plan the user enters the virtual 3D VRML model of the correspondent room. In addition to the real-world-like navigation through the whole interior space the user can also select all available items of the room infrastructure, e.g. desks, chairs, radiators, lamps or basins. Every single infrastructural object is connected via VRML anchor objects with a PHP query on a relational MySQL database. The database is used for the management of all relevant data according to the four component groups of a campus infrastructure as described above. The successful and error-free completion of the PHP query generates an HTML output with a CSS styled layout. The resulted web page contains all specific information about the selected 3D object, i.e. the Object Details. The full range of unique characteristics of the infrastructural object like spatial dimensions, category, manufacture date, initiation and serial number are displayed in a user-friendly table form. Thus, an interactive and practical web application on the basis of a complex and highly detailed 3D campus infrastructure model is entirely achieved.

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[1] Prof. Dr.-Ing. habil. Peter Sobe, Scientific leader of the ISCID project. Co-operative PhD thesis with the University of Applied Scienes.

[2] ISCID (**I**nformation **S**ystem for **C**ampus **I**nfrastructure **D**ata) – http://www.htw-dresden.de/~v3cim – supported by the Saxon State Ministry of Sciences and Arts.

Research Contracts

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 project No. 260088

Budget/Funding: 4.6 million Euro / 2.7 million Euro (total), 0.6 million Euro (CIB)

Duration: 3.3 years, since 09/2010

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. The HESMOS results were shown on three public workshops - (1) Munich, Oct. 2012, (2) Munich, Sept. 2013, in the frames of the BuildingSMART International BIM Week, and (3) Amsterdam. Presentations are available via the Project Web site.

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 (Germany),
Obermeyer Planen + Beraten GmbH (Germany),
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– EC FP7 project No. 288819
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 architectural and HVAC design to a Virtual Energy Laboratory (VEL). 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 of the project is the stochastic modelling of various lifecycle influences such as climate, occupancy and material properties.

The focus of the prototype application domain is on buildings 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 (as part of the VEL), based on an interoperable ontology-supported platform customizing advanced Cloud technologies. The focus of the research is on (1) multi-model design and testing, (2) stochastic analysis/simulation in combination with a new supporting ontology and interoperability tools and services, and (3) respective re-engineering of existing tools, making them more intelligent and smartly interoperable. Further goals are the combination of energy profile modelling templates with product development STEP models and building and facility BIM models.

The developed Virtual Energy Lab is an extension of the platform achieved in the HESMOS project. It is 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. Using the ISES services, practitioners will be able to concentrate their efforts on energy-aware design decisions, facilitated by the VEL modelling and computational cloud-enabled capabilities.

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:	**eeEmbedded – Collaborative Holistic Design Laboratory and Methodology for Energy-Efficient Embedded Buildings** http://eeEmbedded.eu
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dr.-Ing. P. Katranuschkov
Financial Support:	EU – EC FP7 Integrated Project No. 609349 (EeB.NMP.2013-5 Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems)
Budget/Funding:	11.10 million Euro / 7.65 million Euro (total), 1.26 million Euro (CIB)
Duration:	4 years, since 10/2013
Approach:	**eeEmbedded** will provide an open BIM-based holistic collaborative design and simulation platform, a related holistic design methodology, an energy system information model and an integrated information management framework for designing energy-efficient buildings and their optimal energetic embedding in the neighbourhood of surrounding buildings and energy systems. A new design control and monitoring system based on hierarchical *key performance indicators* (KPI) will be developed to support the complex design collaboration process. Knowledge-based detailing templates will allow energy simulations already in the early design phase, and BIM-enabled interoperability grounded on a novel system ontology will provide for a seamless holistic design process with distributed experts, and a seamless integration of simulations in the virtual design office (energy performance, CO_2, CFD, control system, energy system, climate change, user behaviour, construction, facility operation), thus extending it to a real *Virtual Engineering Lab*. A test period of 12 project months, overlapping the first 42 development months of the project, will provide for real pre-market validation of the system on two real embedded buildings of different types. The development work will be based on 2 business models – the business model of the owners (and hence the equipment providers), and the business model of construction and design companies. Applications and services of the eeEmbedded platform will built upon a set of ISO and industry standard data structures and specifications such as IFC, STEP, CityGML, RDF and OWL to enable greatest commonality and inter-company operability of the developed ICT solutions. A new ontology-based Link Model, substantially extending the ontology set up in the EU project ISES, will provide the bridge between the multiple physical and mathematical models involved in the eeBuilding domain, thereby warranting the desired data and services interoperability. In addition, a general-purpose energy simulation model (ESIM) will provide the necessary prerequisite to plug in different computational tools on the platform, such as the energy analysis tools NANDRAD and TRNSYS-TUD of the TU Dresden or EnergyPlus, CFD analysis tool of SOFiSTiK, Greece, and tools based on Modelica, etc. Baseline for all ICT services will be the developed methodology for BIM and KPI-based eeeDesign and the related overall ICT framework of the Virtual Engineering Lab, which will be elaborated in four application domains: (1) building thermal design, (2) building energy embedding design based on ESIM, (3) building sensor and control system design, and (4) eeConstruction planning and embodied energy design. On that basis, new ways of facility management will be suggested and forwarded to AEC/FM practice.
Partners:	TU Dresden , Institute of Construction Informatics – **Coordinator**, and Institute of Power Engineering (Germany), Fraunhofer Gesellschaft - Institute IIS/EAS (Germany) Nemetschek Allplan Slovensko (Slovakia), Data Design Systems ASA (Norway), RIB Information Technologies AG (Germany), Jotne EPM Technology AS (Norway),Granlund Oy (Finland), SOFiSTiK Hellas AE (Greece), iabi - Institute for Applied Building Informatics (Germany), Fr. Sauter AG (Switzerland), CEMOSA (Spain), Obermeyer Planen + Beraten GmbH (Germany), STRABAG AG (Austria), Royal BAM Group nv, AZ (The Netherlands)

Title:	**HOLISTEEC - Holistic and Optimized Life-cycle Integrated SupporT for Energy-Efficient building design and Construction**
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dipl. Ing. Hervé Pruvost
Financial Support:	EU – EC FP7 Collaborative Project No. 609138 (EeB.NMP.2013-5 Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems)
Budget/Funding::	9.7 million Euro / 6.5 million Euro (Total), 0.45 million Euro (CIB)
Duration:	4 years, since 10/2013
Approach:	Despite recent evolutions of tools/practices in the Architecture Engineering, Construction and Facility Management have already resulted in considerable advances, some limitations remain, related to the complexity and variability of building life cycles, addressing building end user awareness and participation, lack of new business models, life cycle fragmentation, limited interoperability of the ICT supports. The main objective of HOLISTEEC is thus to design, develop, and demonstrate a BIM-based, on-the-cloud, collaborative building design software platform, featuring advanced design support for multi-criteria building optimization. This platform will account for all physical phenomena at the building-level, while also taking into account external, neighbourhood-level influences. The design of this platform will rely on actual, field feedback and related business models / processes, while enabling building design & construction practitioners to take their practices one step forward, for enhanced flexibility, effectiveness, and competitiveness. HOLISTEEC main assets are: (i) an innovative feedback /loop design workflow (ii) a multi-physical, multi-scale simulation engine; (iii) A unified data model for Building and Neighbourhood Digital Modelling (iv) a full-fledged open software infrastructure for building design tools interoperability leveraging available standards; (v) innovative and flexible user interfaces. HOLISTEEC is expected to have a direct impact at a macro level on the construction sector as a whole, through the following aspects: improved overall process efficiency, improved stakeholders collaboration and conflict resolution, lifecycle cost reduction, reduction of errors and reworks. These impacts will be quantitatively evaluated during the demonstration and validation phase of the project, where the proposed design methodology and tools will be extensively applied to four real construction projects, in parallel to standard design approaches.
Partners:	D'Appolonia S.p.A.(Italy) – Coordinator, and Koninklijke Bam Groep Nv (Netherlands), Acciona Infraestructuras S.A. (Spain), Nemetschek Slovensko S.R.O. (Slovakia), Senaatti-Kiinteistöt (Finland), Gdf Suez (France), S.T.I. Engineering S.r.l. (Italy), Bergamo Tecnologie Sp Zoo (Poland), Cype Soft S.l. (Spain), G.E.M. Team Solutions Gdbr (Germany), Geomod S.a.r.l. (France), Pich-Aguilera Arquitectos S.L.P (Spain), Centre Scientifique et Technique Du Batiment (France), Commissariat A L'Energie Atomique Et Aux Energies Alternatives (France), Fundacion Tecnalia Research and Innovation (Spain), Technische Universitaet Dresden (Germany), Teknologian Tutkimuskeskus Vtt (Finland), Institut Für Angewandte Bauinformatik (Institute For Applied Building Informatics) (Germany), National Taiwan University Of Science And Technology (Taiwan).

Title:	**Design4Energy** – **Building life-cycle evolutionary Design methodology able to create Energy-efficient Buildings flexibly connected with the neighborhood energy system.**
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dipl.-Inf. Dipl.-Ing. Mathias Kadolsky
Financial Support:	EU – EC FP7 Integrated Project No. 609380 (EeB.NMP.2013-5 Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems)
Budget/Funding:	6.5 million Euro / 4.9 million Euro (total), 0.4 million Euro (CIB)
Duration:	4 years, since 10/2013
Approach:	**Design4energy** will develop an innovative Integrated Evolutionary Design Methodology that can allow the stakeholders to predict the current and future energy efficiency of buildings (both at individual level and neighbourhood level) and make better informed decision in optimising the energy performance at building life cycle level, including operation and maintenance. Visualizing the future will provide to design energy efficient building not only for the present but also for the future, ensuring an Energy Efficient Life Cycle of the building. The Design4energy project will take this into consideration and will develop tools and methodologies, that can help designing energy efficient buildings, that can consider both short term performance as well as future scenarios, considering important factors such as deterioration curves, technology evolution, climate change effect, users, energy neighbourhood configuration, continuous commissioning alternatives while evaluating their impact in the Building Life Energy Performance. The continuous commissioning will include strategies as preventive maintenance, renovation of energy systems technologies (HVAC, RES, etc.), including deep retrofitting strategies. The proposed methodology will be based on a sophisticated technology platform, that will make use of energy attributes of building components, deterioration of building components and systems, neighbourhood energy systems, energy related parameters, energy simulation tools and current usage parameters of the tenants, derived from maintenance and operation data. The technology platform developed within the Design4energy project will allow the stakeholders to explore various design options and make validated and qualified choices as early as possible.
Partners:	SOLINTEL M&P SL (Spain) – **Coordinator**, TU Dresden - Institute of Construction Informatics (Germany), Teknologian tutkimuskeskus VTT (Finland), 3L-Plan Lenze-Luig-Walter GbR (Germany), Loughborough University - Construction Informatics (UK), Fraunhofer Gesellschaft - Institute IAO (Germany), UNINOVA (Portugal), Corio nv (Netherlands), University of Salford - School of the Built Environment (UK), SISTEMAS Y MONTAJES ELECTRICOS SL (Spain); IZNAB Sp. z o.o (Poland), Gaspar Sanchez Moro Arquitectos S.L.P. (Spain), Metropolitan Research Institute Ltd. (Hungary), ANCODARQ S. L. (Spain), CADCAMation KMR SA. (Switzerland), TPF Sp. z o.o. (Poland), Assignia Infraestructuras SA. (Spain)

Title:	**BridgeCloud-Model-Based Aeroelastic Analysis of Long-Span Bridges on the HPC Cloud**
Project Leader:	Prof. Dr.-Ing. R. J. Scherer Co-leader: Dipl. Ing. Ali Ismail
Financial Support:	EU– Eurostars Nr. E! 7987; BMBF (German Ministry of Education and Research)
Budget/Funding:	2.6 million Euro/1.8 million Euro (total), 0.30 million Euro (CIB)
Duration:	3 years, since 07/2013

Approach:

BridgeCloud aims to develop a bridge-wind interaction virtual design lab for the combined Fluid-Structure interaction analysis of aeroelasticity phenomena in long/medium span bridges, that integrates semi-automatic modelling on a BIM basis, numerical wind-bridge interaction analysis and cloud computing power, providing for an easy-to-use sophisticated design tool to bridge design through SMEs. The virtual design lab will enhance the design by shifting the experimental phase (virtual wind tunnel tests) towards the early stages of the whole design procedure, thus facilitating testing and comparison of alternative bridge typologies, and optimizing bridge design in all design stages. By performing all necessary design tasks in-house, structural design office productivity will be improved, and by optimizing the structural system and bridge cross-sections, the overall construction cost will be reduced. The interaction between the fluid flow and an embedded elastic body is extremely complex. The aeroelastic instability includes phenomena like vertical due to vortex shedding phenomenon induced by the flow over bluff bodies, torsional, and coupling of vertical and torsional instability, called flutter. If the wind speed is greater than the critical wind speed the aerodynamic instability develops, which leads to failure.

Aerodynamic aspects will become a major design factor in bridge engineering. As the design of long-span bridges, and other slender structures, becomes ever more ambitious, each new design challenges further the available technology. The most important factor in the performance of such structures is their tendency to move under the influence of aerodynamic forces in a way governed by a complex interaction of wind and structure. Wind tunnel testing is the standard procedure for the assessment of the aerodynamic behaviour of bridge decks, but numerical methods will offer detailed insight into the flow properties.

BridgeCloud aims to revolutionize everyday bridge design by developing a methodology and producing a corresponding software product for (i) obtaining wind pressure distributions in space and time accounting for fluid (wind) – structure (bridge) interaction, (ii) automatically incorporating them into the structural design process, and (iii) capturing and avoiding eventual aerodynamic instability effects that may endanger long-span bridges.

Partners:

FIDES DV-Partner Beratungs- und Vertriebs-GmbH, (Germany) – **Coordinator**

TU Dresden, Institut für Bauinformatik

Wacker Bauwerksaerodynamik GmbH, (Germany)

DENCO Development and Engineering Consultants S.A,(Greece)

Institute of Bioorganic Chemistry Polish Academy of Science-Poznan Supercomputing and Networking Center, (Poland)

Title: **SE-Lab - A Cloud-/Grid-Based Virtual Laboratory for Non-Linear Probabilistic Structural Analysis**

http://www.selab.eu

Project Leader: Prof. Dr.-Ing. R. J. Scherer
Co-leader: Dipl.-Ing. Ronny Windisch

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., (Czech Republic) – **Coordinator**

Leonhardt, Andrä und Partner, Beratende Ingenieure, VBI, GmbH, (Germany)

TU Dresden, Institut für Bauinformatik

Title:	**eWorkBau – Webservice-based multi-media teaching and learning concept for craftspeople's training in mobile model-based working methods**
	http://ework-bau.de/
Project Leader:	Prof. Dr.-Ing. R. J. Scherer
	Co-leader: Dipl.-Ing. (Arch.) Helga Tauscher
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:

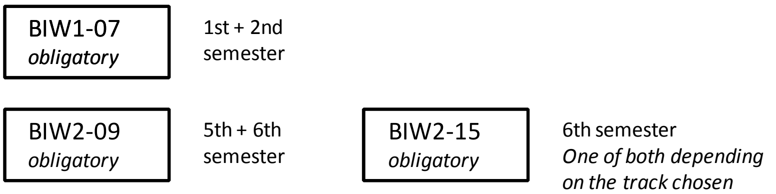
Interessengemeinschaft des Heinz-Piest-Instituts an der Leibniz-Universität Hannover e.V. – **Coordinator**,
AEC3 Deutschland GmbH (München),
Dachdeckermeister Claus Dittrich GmbH & Co KG (Dresden),
Handwerkskammer Koblenz,
Handwerkskammer Münster,
Zentralstelle für die Weiterbildung im Handwerk Düsseldorf,
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.

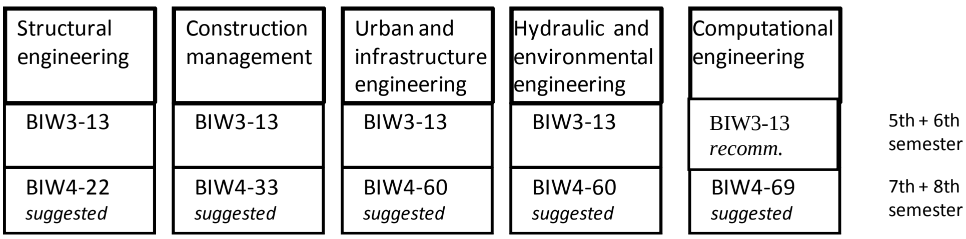
Lecture Activities

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 of 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, Kreil

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/Opitz, 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/Opitz

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/Windisch

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, Reuter/Katranuschkov, Windisch

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/Katranuschkov, Kreil

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 7^{th} 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/Pruvost

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.

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 2013

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[2] ESFAHANI N. N., Interoperability methods for Infrastructure Design and Information Systems, in: Proc. 25th Conference "Forum Bauinformatik", Munich, Germany, 18-20 September 2013.

[3] FUCHS S., NITYANTORO E., BIM-Methods for managing multi-models (in German: BIM-Management von Multimodellen), In: Scherer R. J., Kreil R. & Opitz F. (eds.) Proc. 4. Fachkonferenz Bauinformatik – Baupraxis, Dresden, Germany, 26 September 2013.

[4] GURUZ R., BALARAS C.A., KAVČIČ M., Energy related key performance indicators (eKPIs) as valuable insight for improving a building's energy design and operation, In: Scherer R. J., Kreil R. & Opitz F. (eds.) Proc. 4. Fachkonferenz Bauinformatik – Baupraxis, Dresden, Germany, 26 September 2013.

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[9] KOG, F., GOK, M.B., Petri Net based Verification and Reconfiguration of BPMN Represented Configured Construction Processes, in: Proc. of 25th Conference "Forum Bauinformatik", Munich, Germany, 18-20 September 2013.

[10] KREIL R., OPITZ F., POLTER M., Knowledge-based virtual lab for geotechnical survey (in German: Wissensbasiertes virtuelles Ingenieurlabor für geotechnische Überwachung), In: Scherer R. J., Kreil R. & Opitz F. (eds.) Proc. 4. Fachkonferenz Bauinformatik – Baupraxis, Dresden, Germany, 26 September 2013.

[11] LIEBICH T., KATRANUSCHKOV P., WEISE M., GURUZ R., eeBIM: Extending BIM for Multi-Model Domain Tasks, In: Proc. 1st ICT4SP Int. Conf. (ICT for Sustainable Places), Nice, France, 9-11 September 2013.

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[13] SREWIL Y., Enhancing of construction process planning and control with Cyber-Physical Approach based RFID, in: Proc. of 25th Conference "Forum Bauinformatik", Munich, Germany, 18-20 September 2013.

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Positions in Editorial Boards of Journals

Advanced Engineering Informatics	Elsevier Publishers	The Netherlands
Automation in Construction	Elsevier Publishers	The Netherlands
Information Technology in Construction (electronic journal)	Intl. Council for Research and Innovation in Building and Construction (CiB)	The Netherlands
Construction Innovation	Emerald Group Publishing	UK
Design Sciences and Technology	European Productions	France

Membership in Standardization Groups

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