TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUT FÜR BAUINFORMATIK

PROF. RAIMAR J. SCHERER

JAHRESAUSBLICK

RESEARCH AND LECTURE ACTIVITIES IN 2015

December 2014

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 2015. Research topics are: building information modelling, multimodels, interoperability, generic model filters, intelligent construction management, virtual organizations, project risk management, dynamic process modelling, simulation, e-learning, and design, ICT for construction and operation of energy efficient buildings. Most of the topics have been accumulating in our ongoing common development "An intelligent Virtual Engineering Lab (iVEL), which bridges the BIM 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.

2014 was a year of consolidation and of successfully finishing our first two research projects on energy efficiency, HESMOS and ISES ending on 20.03.2015 with the final review and 30.11.2014, resp. The intelligent Virtual Energy Lab yielding from these projects is a great success and has been asked for from various sides. As a result, an interest group for an open source kernel for an energy efficient platform was founded in Athens in October 2014. It is supported by individuals mainly coming from the EU projects Design4Energy, eeEmbedded, HESMOS, HOLISTEEC, ISES, and STREAMER. Bylaws and objectives have been drafted in Athrens and the next meeting is scheduled for March 2015. Membership is on a personal basis, signing a Letter of Intent, which can be downloaded from *http://bci53.cib.bau.tu-dresden.de/loi/document.pdf* . A website will be launched in April 2015 after the next meeting and can be accesses from our website. A lot of our resources were concentrated on finalizing a 2-volume book about Information Systems in Construction (in German: Informationssysteme im Bauwesen), which will be released by Springer in December 2014. The book is dedicated to the new way of multimodel working, explains the basic theory of multimodels and shows their beneficial application in all areas of information management in construction, including simulations of the construction process and risk management. It covers almost all the research results of the German integrated research project Mefisto and some results of several other research projects of the institute. The first versions of our multimodel BIM tools has gone online and can be reached at *http://mefisto-bau.de/resources/resources_software.html*, namely the filter toolbox BIMFIT, the multimodel container viewer and manager M2A2, the construction simulation toolkit CST, the multimedia visualizer Billie, and the information access tool BIMcraft. The multimodel container method and the lean IDM interoperability method have been adapted by buildingSMART for recommendation and standardization and the first MMC group of buildingSMART is going to finalize the first recommendation document on the multimodel container in the first quarter of 2015. The first VDI working group for BIM recommendations is meanwhile very active and has successfully installed several domain specific working groups showing good progress (*http://www.vdi.de/technik/fachthemen/bauen-und-gebaeudetechnik/querschnittsthemen-der-vdi-gbg/koordinierungskreis-bim/).* Our flagship iVEL has continuously been growing concerning its functionality and the handover from the former researchers who has left the institute to new ones has been working quite well thanks to the team spirit at the institute. iVEL has been rather well adopted and further developed in all our current research projects, in which we are either coordinator or partner.

The institute strongly promotes ICT in research and industry. Prof. Scherer is chairman of the European Association of Product and Process Modelling, which held its 10^{th} ECPPM conference in Vienna, Austria, from 17^{th}-19^{th} September 2014 (*http://www.ecppm.org*). The ECPPM started in 1994 and is the oldest BIM conference. In conjunction with the 10^{th} ECPPM, the 5^{th} Workshop on ee-Building Data models was held, which underpins the importance of BIM methods for energy efficient design and maintenance of buildings. The next ECPPM will be held in Cyprus in September 2016.

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 5^{th} conference "Bauinformatik – Baupraxis" (construction informatics – construction practice) in Dresden, supported by the "Dresdner Bauinformatik-Gesprächskreis" (Dresden Construction Informatics Roundtable) on the topic BIM for handicraftpersons.

E-learning activities have been extended with the project eWorkBau, which focuses on the interfaces for BIM access and a domain BIM query language, both embedded in e-learning courses. The achieved results were shown in the abovementioned conference. The European online Master course "IT in Construction", coordinated by the University of Maribor, Slovenia, is now in its 11th academic year and students can enrol at 7 European universities.

In September 2014, Jamshid Karami left the institute for his home university in Iran to continue his lecture activities there and at the end of December Frank Hilbert left the institute for a position in the industry. The competence of the institute has been strengthened by two mathematicians, Tom Grille and Robert Schülbe whose work will focus on stochastic and topological modelling, resp.

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 2014. Dr. Robert Klinc 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 institute again hosted a few students from the Lebanese American University for a 6-week period, who gathered experience in construction informatics research.

Several members of the institute have received awards. Sebastian Fuchs has got a prize for the best annual ICT software in construction informatics from the German ministry of construction and infrastructures at the annual construction fair. Ali Ismail has received the best-paper award at the 13th International Conference on Modelling and Applied Simulation, Bordeaux, France.

Prof. Scherer has received the Konrad-Zuse-Medaille from the association of construction companies for his merits in construction informatics. This medal is the highest German prize of construction informatics awarded biannually in honour of Konrad Zuse, who invented and built the first computer in the world in Berlin during his civil engineering studies in 1943. In the altering years the prize is awarded to computer scientists by the association of computer sciences.

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

Dresden, in December 2014 Raimar J. Scherer

Institute of Construction Informatics

		Phone extension	Email name
Head of Institute	Prof. Dr.-Ing. Raimar. J. Scherer	3 35 27	Raimar.Scherer
Leading engineer	Dr.-Ing. Peter Katranuschkov	3 22 51	Peter.Katranuschkov
Head IT Lab	Dr.-Ing. Uwe Reuter	3 57 28	Uwe.Reuter
Secretary	Ilona Jantzen	3 29 66	Ilona.Jantzen
	Dipl.-Ing. Kathrin Binye	4 25 40	Kathrin.Binye

Teaching staff

Dipl.-Ing. Frank Opitz	3 97 75	Frank.Opitz
Dipl.-Ing. Robert Kreil	4 28 38	Robert.Kreil

Researchers

Dipl.-Medieninf. Ken Baumgärtel	4 25 42	Ken.Baumgaertel
MSc Alexander Benevolenskiy	3 57 42	Alexander.Benevolenskiy
Dipl.-Ing. Arch. Romy Guruz	4 25 44	Romy.Guruz
Dipl.-Math. Tom Grille	3 97 75	Tom.Grille
Dipl.-Inform. Mario Gürtler	4 28 37	Mario.Guertler
MSc Ali Ismail	3 45 30	Ali.Ismail
Dipl.-Ing. Dipl.-Inf. Mathias Kadolsky	4 25 43	Mathias.Kadolsky
MSc Faikcan Koğ	3 57 45	Faikcan.Kog
Dr.-Ing. Marc Mosch	4 28 34	Marc.Mosch
MSc Eko Nityantoro	3 36 71	Eko.Nityantoro
Dipl.-Phys. Frank Noack	4 28 41	Frank.Noack
Dipl.-Medieninf. Michael Polter	4 25 39	Michael.Polter
MSc Hervé Pruvost	3 57 42	Herve.Pruvost
MSc Ksenia Roos	4 28 35	Ksenia.Roos
Dipl.-Math. Robert Schülbe	3 49 57	Robert.Schuelbe
MSc Yaseen Srewil	3 97 76	Yaseen.Srewil
Dipl.-Ing. Arch. Helga Tauscher	4 25 41	Helga.Tauscher

PhD students extern

Dipl.-Ing. Alexander Gehre	Alexander.Gehre@semproc.de
Dipl.-Ing. Sebastian Fuchs	Sebastian.Fuchs
Dipl.-Medieninf. Frank Hilbert	Frank.Hilbert
MSc Hermin Kantardshieffa	kantards@informatik.htw-dresden.de
MSc Jamshid Karami	Jamshid.Karami
MSc Nazereh Nejatbakhsh	Nazereh.Nejat@opb.de
Eugenie Pflaum	eu.pflaum@googlemail.com
MSc Sven-Eric Schapke	sven-eric.schapke@thinkproject.com
Dipl.-Ing. Ulf Wagner	Ulf.Wagner
Dipl.-Ing. Ronny Windisch	Ronny.Windisch

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

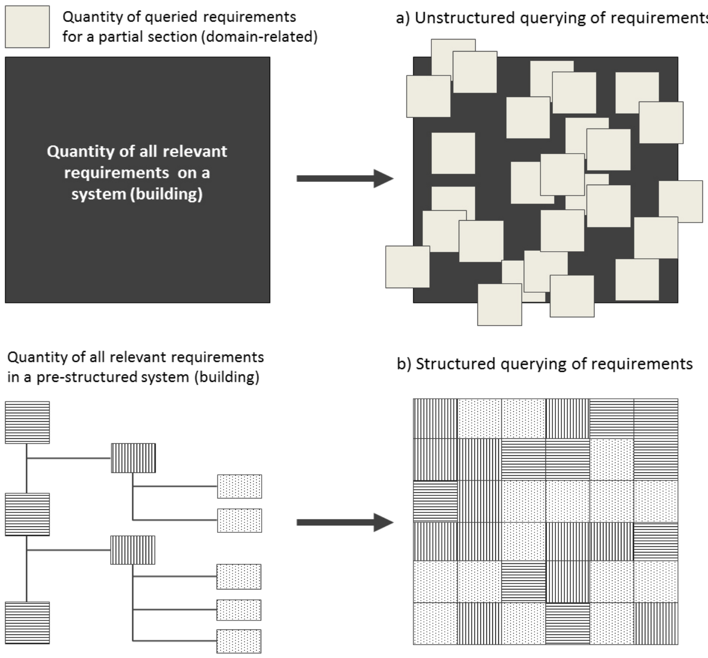
Overall the employees at the institute cover a broad range of expert domains as well as languages with researchers from Bulgaria, France, Iran, Russia, Syria, Indonesia and Turkey.

Method for a Continuous Management of Building Requirements during Building Design Processes

Romy Guruz

Objectives

One major challenge in building planning processes lies in the multitude of the participating planning partners and the combination of their domain-specific requirements in view of the overall design focus. Although building requirements (BRs) can be classified into 4 groups: Client, regulatory, environmental and site requirements, but behind each of these groups arise a variety of implicit and explicit requirements which can be partially contradictory. Usually, after deciding on the design focus by the client, the participating planners derives and prepares their own domain-related requirements. After this, a constancy check is needed where all collected requirements are consolidated and smoothed in several iterations by the architects and the participating domain experts. Moreover, this process is repeated after completing each planning step. This work is focused on the integration of BRs management in the planning process, following the example of systems engineering. Previous approaches for a data-related integration of BRs are primarily concerned with the domain-related preparation of the data (upper part of the figure) and resulting in redundant queries and gaps at the boundaries between the domains. To solve these problems, a pre-structured hierarchical structure is intended which allows a higher-level integration of these methods (lower part of the figure). Furthermore, logical conjunctions between the modules of the structure may help to support modification and updates of BRs and make visible their influence(s) on other modules.



a) Current method of querying BRs; b) Preparation phase of BRs management

Approach

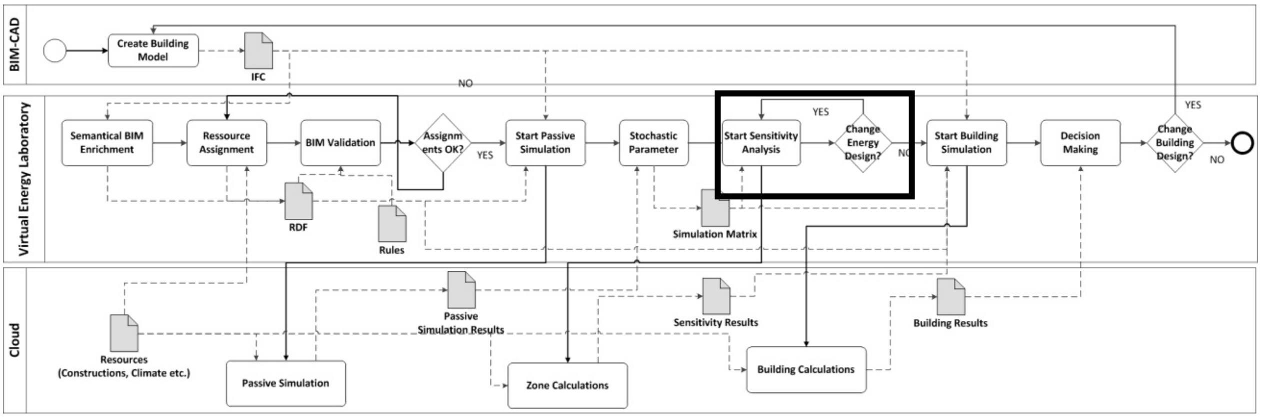
The proposed method is divided into 3 phases 1) preparation, 2) specification and 3) utilization phase of BRs. In the 1) preparation phase, firstly a generic structure is created based on the combination of building functions (which represents the clients view) and building elements (which represents the planners view). The subsystems under a hierarchical level have to be unambiguously defined and their interfaces are classified in only one subsystem. This structure enables also the re-using of collected information from previous projects and is usable as basis for future projects too. In the 2) specification phase, all participating planners integrates their guidelines to be observed such as values, regulations, agreements so on. Each subsystem is only assigned to the involved planers by dint of predefined attribute(s). To ensure a continuous using of BR during the 3) utilization phase, a common data repository is needed. Caused the change in another subsystem additional adaption, the impacts on the entire system or working process become visible. The method under consideration may also form the base for verifiable design checkpoints. It enables structured definition and formalization of these *Key Points* (via rules and/or algorithmic constituents) with regard to the project related design focus.

Improved Energy Simulation Workflow for Optimizing Energy Design Variants through Ontology Rules

Ken Baumgärtel

Objectives

To enable energy simulations the building information model must be combined with additional information resources like thermal conductivity values for materials or climate test reference years with outdoor temperatures and radiations. Multi models such as ontologies pursue the way of providing the interoperability through different elementary models, e.g. the building information model, while creating links between objects of each model so that a new state is created based on these linkages and not on changes of one holistic model that integrates all needed information. With such a multi model various energy simulations can be started, e.g. thermal passive simulations, CFD simulations or sensitivity analyses. In the sensitivity analysis resource assignments are varied so that multiple input parameters are created which leads to a huge amount of energy results that must be evaluated to select an optimized energy design. This optimization is a complex task which needs much configuration time and can partially are done in an automatic way where the user only defines value ranges of key performance indicators for energy design variants.



Energy simulation workflow in the current prototype and the envisaged improvement

Approach

The overall workflow that was used in the EU project ISES is given in the figure above. Starting from a building information model the assignment of energy resources is stored in a multi model. In former work ontologies were developed that allow the linkage of the building information model to different energy-related models and check of energy-related resource assignments to BIM objects based on constraints and rules. While energy simulations such as passive simulations (without a heating system), the sensitivity analysis and the full building simulations (with a heating system) can be started based on the stored triples that such ontologies provide, rules are supporting the enrichment with engineering knowledge and condition checks. Exemplary rules are translated from the national regulations such as the EnEV of Germany that defines maximum u-values of materials for external walls, windows slabs etc.

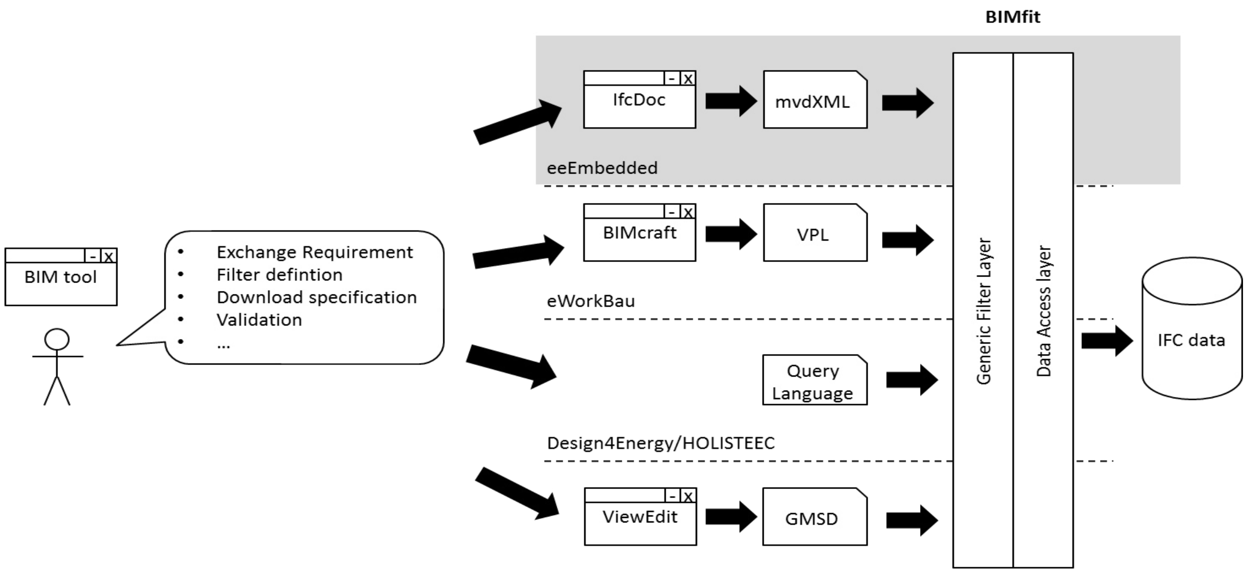
The workflow is fully implemented with manual configuration by the users. To enable a more automatic sensitivity analysis it is foreseen to use ontology rules together with user-defined key performance indicators so that an optimization is driven by constraints and a given logical behaviour within the ontologies. For example, to optimize the insulation of a wall in various climate locations ontology rules can be applied which are describing the algorithm how to vary energy parameters to approximate the key performance indicators. By following this approach it will also be proven how stochastic simulations can be integrated.

Prototypical implementation of mvdXML as possible common access interface for BIM data

Mario Gürtler

Objectives

Industry Foundation Classes (IFC) as standard for Building Information Modeling (BIM) provides a huge number of classes to cover up the most domains involved in construction industry. So that all participating actors of a building project can store and share their information via one single data model and advance the collaboration among themselves as a consequence. But domain experts or their BIM software tools are just interested in a part of the whole IFC data model or users are not allowed to have access to whole data model. For this purpose model view definitions (MVD) are developed to define subsets of the IFC schema for particular use. MVD can be used to validate the data containing required information so that a BIM software tool can work with that data. It can also be used to export data or to download data from a server. A MVD can be implemented as query language, as GMSD or as mvdXML which is a XML based model view definition standard developed by buildingSMART. buildingSMART provides also the software tool "ifcDoc" for creating mvdXML out of the IFC schema what is mostly used to define Exchange Requirements (ER) in Information Delivery Manual (IDM) methodology. IDM methodology is used for instance in ongoing EU-projects eeEmbedded. But there is no software tool what is able to parse and to apply mvdXML so that data can be validated, exported or downloaded automatically what is a very important feature in an automatic data processing BIM environment. And so there is a need to address MVD especially mvdXML as standard compared to other MVD approaches also with regard to find a uniform standardized method to access BIM data.



Different implementations of MVDs in different projects using BIMfit

Approach

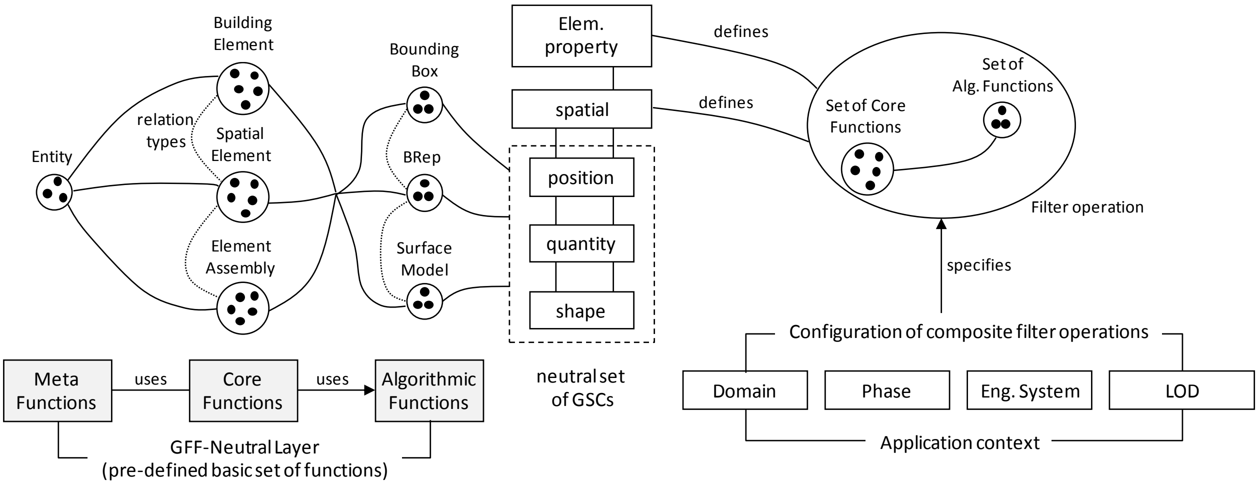
Our filter toolbox BIMfit is already able to handle GMSD, a predecessor of mvdXML, and a proprietary query language what is used in Design4Energy project. As next step mvdXML needs to implement in BIMfit. Whereby the question come up if mvdXML should implemented as single coded solution or as mapping to already existing GMSD or query language. A MVD in mvdXML format can become very complex if the subscripted submodel exceeds a certain size. So the first step will be to apply small examples of mvdXML like if IFC data model contains spatial structure or if it contains the quantity "height" for all walls. In a second step more complex MVD in different formats are applied and compared by using them in the different ongoing EU-projects. As result it can be determined if mvdXML in his current version can be used for validation and for filtering of IFC data and as common access interface for BIM data.

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

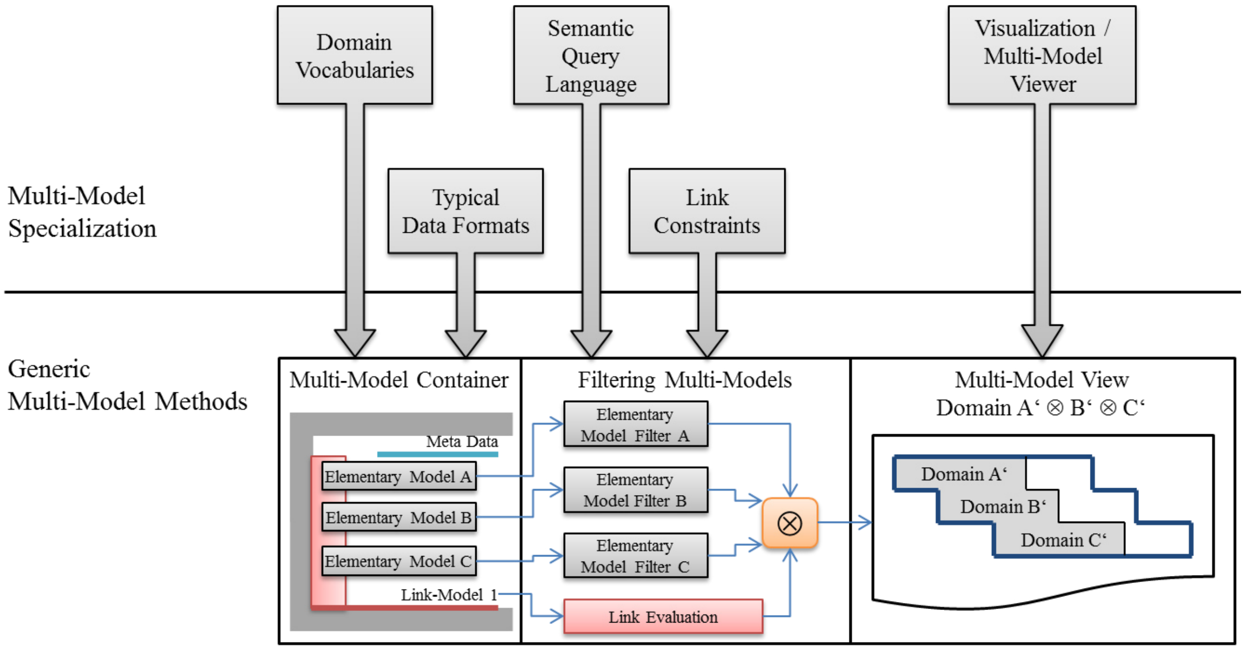
The capabilities for applying geometrical and spatial constraints in information filtering processes shall be embedded into the Generic Filter Framework (GFF) recently developed at our Institute. The GFF concept is based on a breakdown of single application specific filter operations into several reusable 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.

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.

Generating an integrated project information resource by linking document- and multi model-based building information

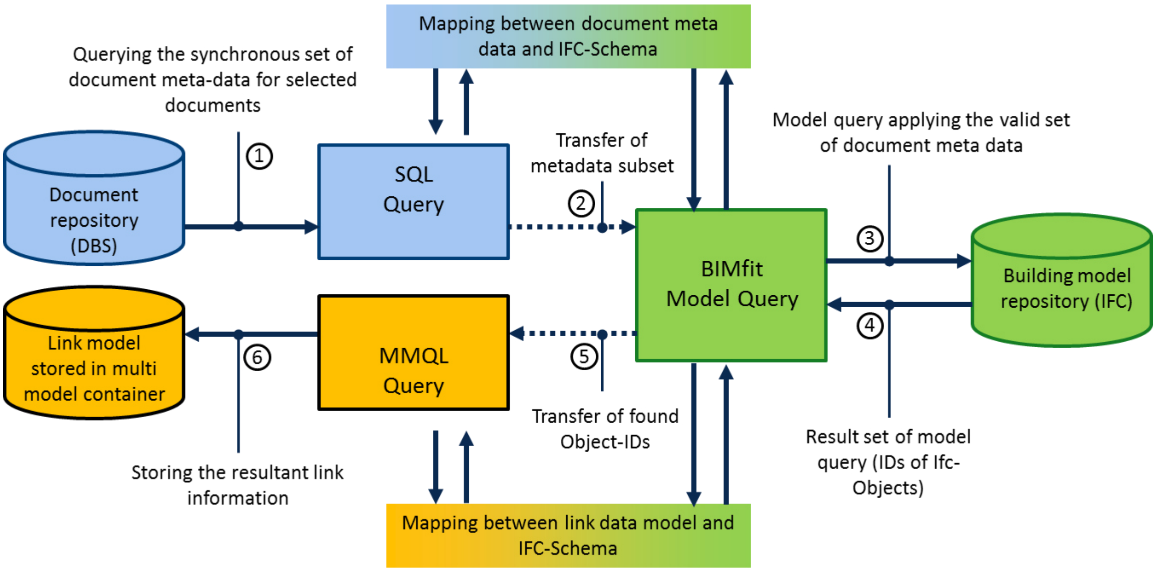
Frank Opitz

Objectives

Traditional semi- and unstructured documents, like formwork or reinforcement drawings, will remain an essential part of the overall project information resources in spite of the BIM based work paradigm and related technologies in the AEC sector. Such kind of documents are still the basis of the daily work in construction projects and are, in contrast to a BIM, valid as mandatory objects of agreement and integral parts of contracts. Therefore document management will remain a crucial part of the overall project management.

The multi model approach covers a wide range of different data models like material data for building elements, activity templates for room and climate templates for buildings exists. A 'data model' for traditional documents is not supported, i.e. the creation of link elements to link documents is not provided.

Based on the fact that in the frames of practical projects traditional documents will coexist together with multi model-based building information the existing technological separation between those different worlds of information is counterproductive and out-of-time since it may cause information losses, inconsistent information resources and hinders an adequate and project wide adoption of BIM technologies.



General link creation process

Approach

Therefore the suggested methodology aims to integrate document and multi model based information resources based on the application of explicit document-object-links which can be generated automatically and stored in the link model of a multi model container. This approach is dedicated to the application in the frames of practical project environments with strong focus on its efficient implementation based on existing multi model consequently utilizing the capabilities offered by open standard and commonly used technologies.

The automated link creation process is based on a set of mapping rules which can be also configured on demand depending on the particular project requirements. The mapping rules specify the corresponding information subsets of both the document metadata and the IFC model data used for link creation. The information subsets specify a type of checksum which is used to identify a valid document-model object pair if the checksum derived from each the document metadata and the building model data is identical.

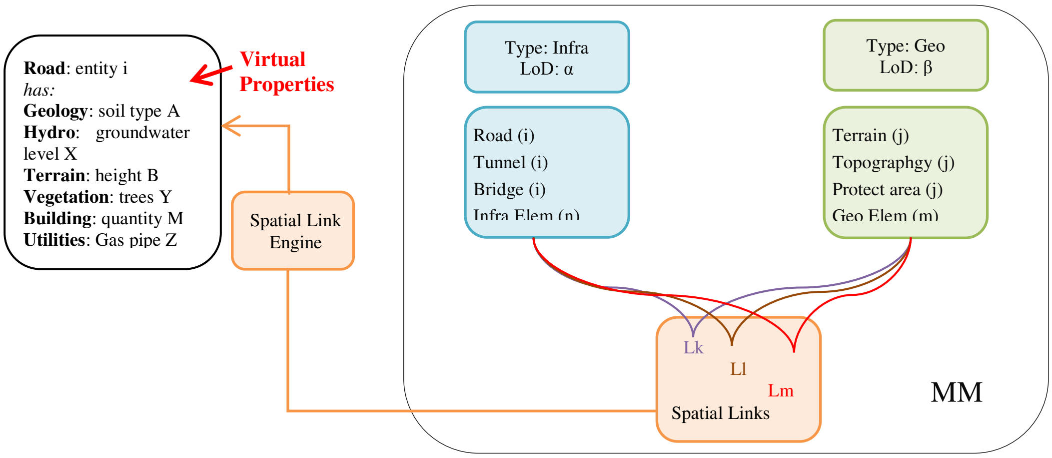
The generated valid document model object set is represented and stored in the link model of a multi model by executing an adapted multi model query language (MMQL) query. Foresighted an implementation in the tool M2A2 is practicable and desirable with regard to promote the BIM paradigm.

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

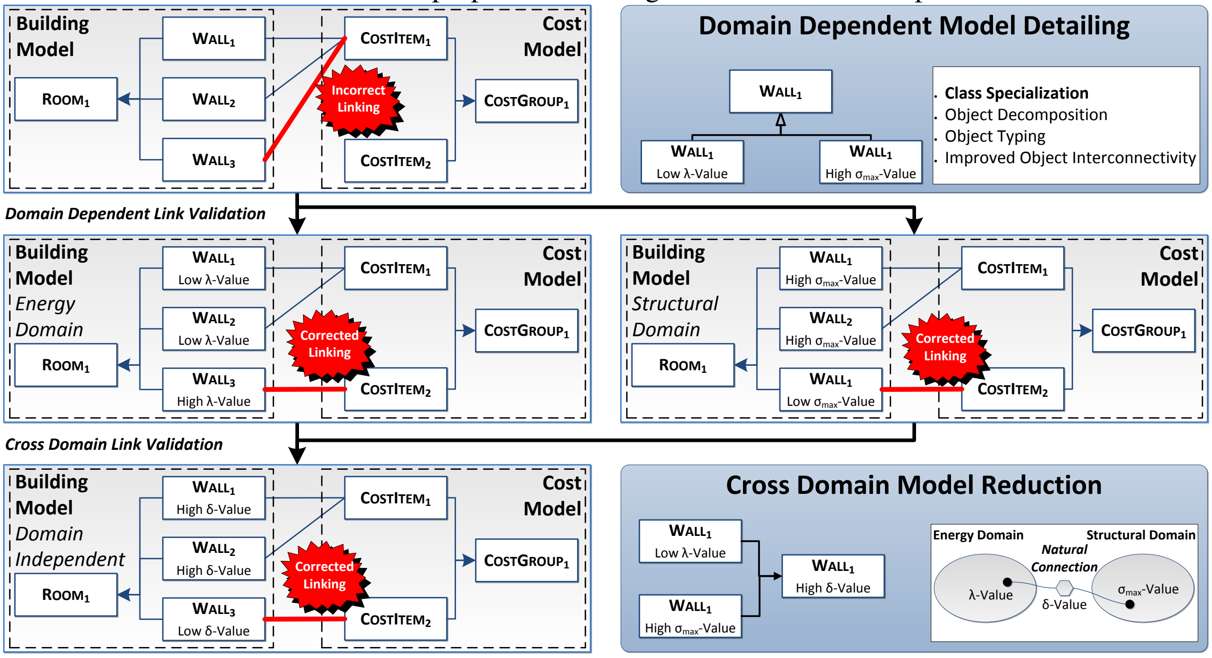
Multi Model (MM) is a method where heterogeneous data models from various domains are bundled together into a container keeping their original format. In separate Link Models the elements of the data models will be linked together. Yet the multi model and the generated links have no inherent domain semantic. 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.

Common Test-Suite for the Validation of Cross Domain Links

Mathias Kadolsky

Objectives

Specific engineering tasks like the structural or thermal analysis of a certain building require next to the building model additional information as input. Usually, these additional information are coming from different domains provided by external sources. To combine the external information with the building model for achieving a task specific multi-model forming the base for the software dependent analysis model different objects have to be connected by links. Besides the realization of the cross domain links the correctness of the links represents an important aspect. Here, the most validation methods aim to provide link checks for a certain domain. This results in large sets of domain dependent validation rules and in time intensive validation procedures required for checking the object links for the different project stages and domain dependent tasks. To make link validation checks more efficient common Test-Suite are proposed covering different domain specific validation rules.



Framework for Common Test-Suite validating Cross Domain Links

Approach

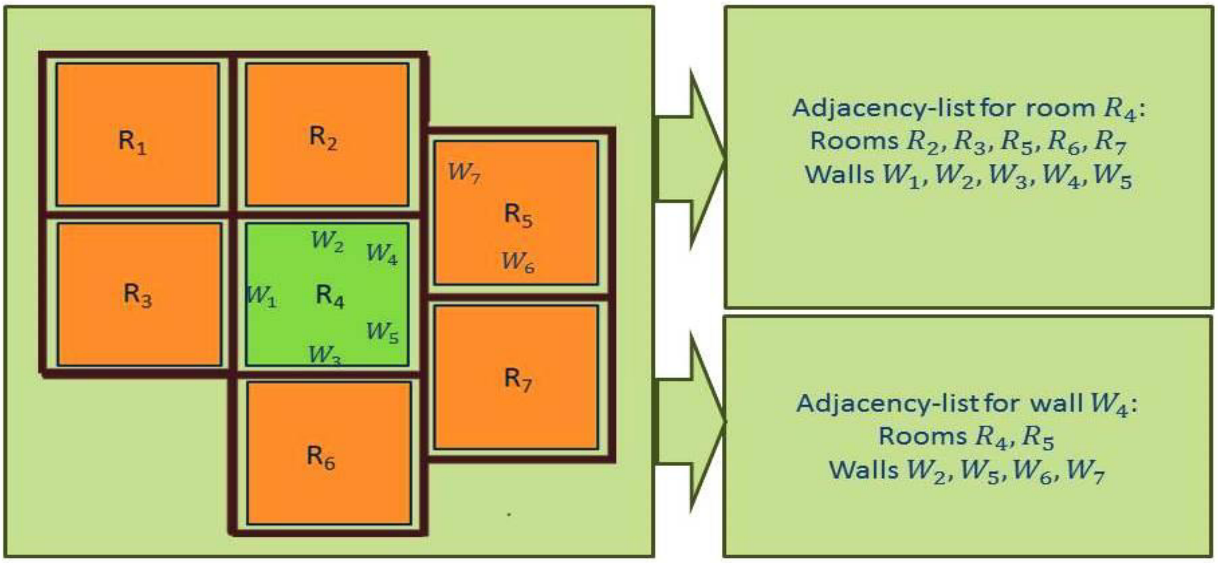
The unambiguous identification of missing or incorrect links requires the definition of obligatory 1:1 relationships between the objects, which should be connected with each other. This kind of relationships is very rarely and to reduce complex relations to such a relation is in the most cases not possible. However, for link validation – not for link setting - such a reduction should be the envisaged goal. Reducing link complexity means detailing the involved models. Thereby, the model detailing could be a class specialization, an object decomposing, an object typing or an improved object interconnectivity, this means an object becomes not exclusive by the direct neighbor, but by an indirect neighbor. Model detailing means describing a certain domain like the building energy domain. The detailing of an object can directly lead to the identification of incorrect links or it can be used as indicator indicating a warning, that two different objects are linked to the same object. While detailing of models is domain specific common validation criteria could be identified. So, the detailing of walls by the λ–value in the energy domain and the detailing of walls by the σ_{max}–value in the structural domain could be reduced to a common detailing by focusing the δ–value of the walls: High δ–values usually correspond to high σ_{max}–values but to low λ–values. The theory behind this kind of reduction is coming from the logical optimization and the search for a minimal Boolean polynomial: For the both domain specific validation rules a common validation rule has to be identified, which is "one", if the domain specific rules are "one". Such common validation rules will be included in a common Test-Suite covering several domain specific link checks by applying only one check. The elaboration of this approach is part of the research work in the eeEmbedded project.

Topology of Buildings

Robert Schülbe

Objectives

Topological information of a building model can be useful for many fields of application, e.g. for energy and occupancy examinations or for questions regarding the connectivity of building systems. Furthermore topological information can be used to filter, e.g. “Find all walls that connect with wall A!”. Presently we face two major problems when examining topological properties of a building. The first problem is the lack of proper and formal definitions regarding topological problems, i.e. there exist no general approach to issues like “When are two rooms adjacent?” or “What is an outer wall of a building?”, in fact even concepts of basic entities like wall adjacency and wall connectivity lack a formal approach. A second problem exists because modern programs often offer the option to include topological information, but this option is almost never obligatory and therefore seldom used. This leads to a situation where we have a complete geometric representation of the building, which also contains the topological information as the former encompasses the latter, yet the latter are not directly available and exist only as part of the geometric model, somewhat hidden from direct access. This research is dedicated to solve both issues. This means that first we have to develop a formal and general approach to definitions regarding topological information and subsequent we will use this formalized definitions to develop algorithms and methods to extract topological information out of a geometric building model.



Obtaining topological information out of a geometrical representation.

Approach

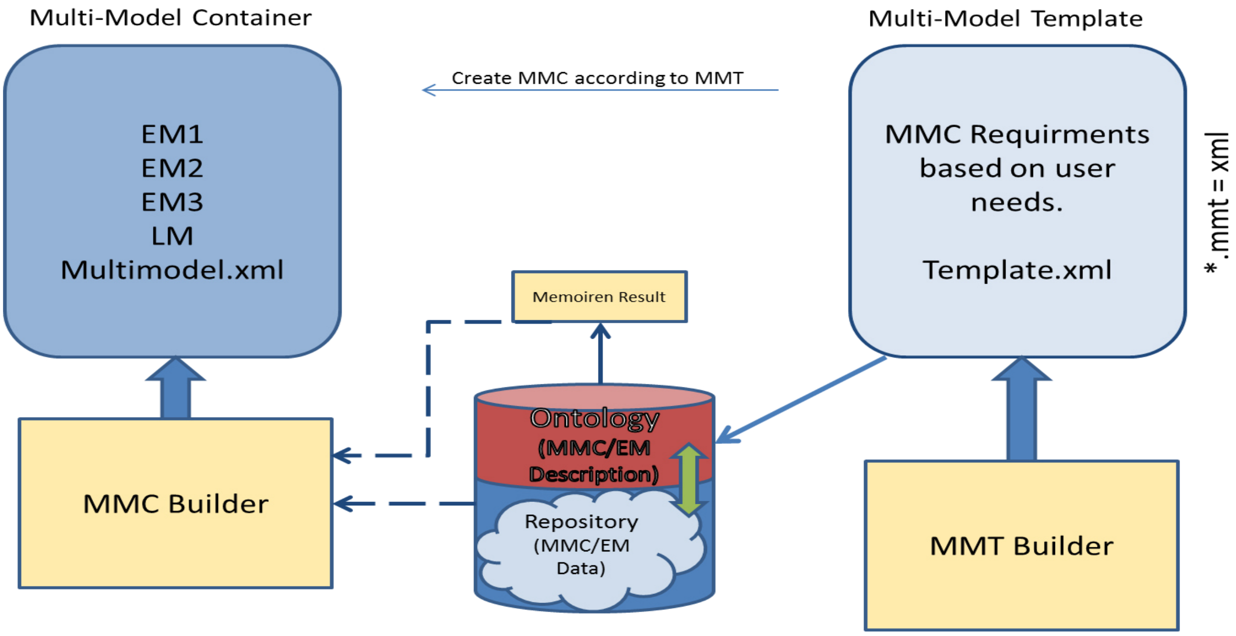
As mentioned a first step in this research is to establish formal definitions for topological values. We will start examining the relations walls and rooms can have with each other and will decide when we see it as appropriate to call elements adjacent. The information gained from this analysis can later be used to similarly develop definitions of topology for other building elements. Examinations of examples have shown that the most promising way to define topological values will be a blend of point set topology and graph theory. The former will be used to decide whether walls connect with each other and the latter to identify rooms, by searching for cycles, and to establish adjacency relations between rooms. With this values defined we will develop an algorithm that uses a geometric representation of a building and in a first step computes the adjacency relations of all walls of a building. In a second step the algorithm then uses these relations to find rooms and to establish adjacency relations for them. At this stage it is possible to derive additional information from the adjacency information through deduction, e.g. information like which walls and rooms lie at the outside of the building. Again this algorithm can later be expanded to compute adjacency relations for other building elements. The final goal will be to have an algorithm which can extract all topological information out of a geometric representation of a building.

Multi Model Management Platform

Eko Nityantoro

Objectives

Multi-model as a media to exchange information should be able to use in different kind of projects. The main goal is, with multi model each participant can share their models, create a model combination, mapping models and even to change the model structure. To build an automation system which can provide an effective solution to share more information, a different cases and a reason is needed. With different cases and different usage of multi model in projects, the system will be able to extract information or solution from its capability to learn. Each projects has different functionality, each projects has different needs of models, and also different solution. Therefore, the platform needs a filter to sort models based on its criteria. For further development, the system will be available as a web service. Which can be also called "**Multi Model One Stop Solution Service**"..



The Collaboration Platform Concept

Approach

Within this platform participant will be able to use the service everywhere without any limitation such as functionalities, data structure, space and even time. The service will provide solutions to create MMT based on their needs, to check the availability of Multi Models, to create Multi Models in Multi model Container, and to register their new Multi model so it can be shared with other participants. This platform will be able to manage collaboration between partners. By collaboration means, each partner will have 'access rights' to access the models based on their discipline and expertise

The collaboration Platform is a web platform. This platform act as a manager and also database provider. This platform will determine which participant can access to certain model provided in the repository or where can they get the required models. This platform also administers the database in the ontology and repository. With The Memoiren Application, participant will be able to search for existing model and register a new model. This collaboration platform will also divide user or participant based on the Projects, expertise and disciplines.

Investigation and Encounter of Risks Evolved from Information Outsourcing in the Building Industry

Marc Mosch

Objectives

In the course of large European projects like HESMOS, ISES and eeEmbedded the Intelligent Virtual Energy Laboratory (IVEL) is developed at the chair of building informatics. Through its example the potential and the risks of two innovations should be examined, which offer visionary solutions for current challenges in the building industry. Both are based on the outsourcing of information to cloud resources.

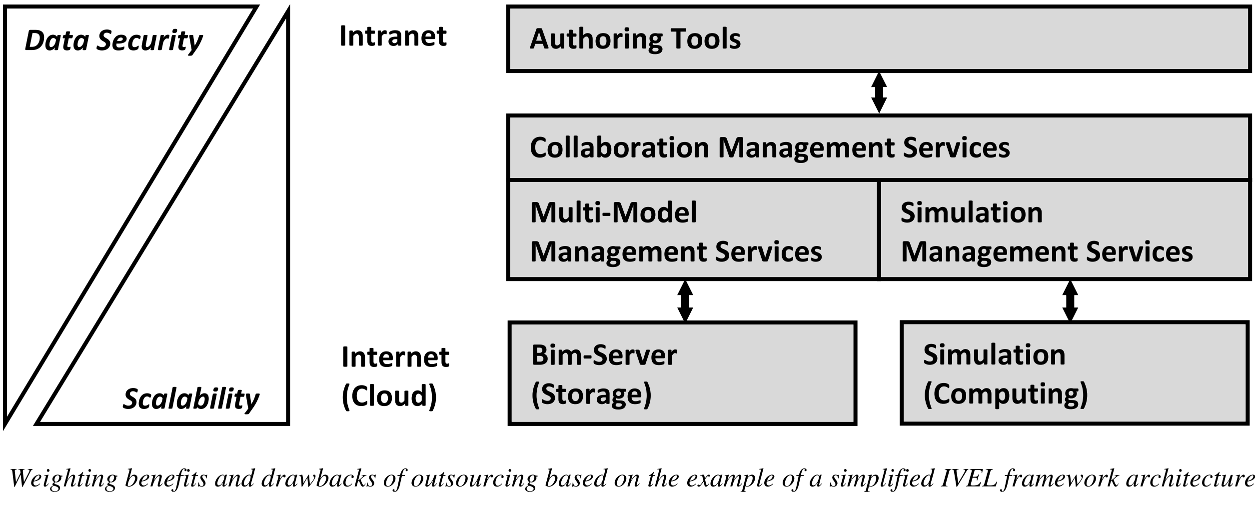
The first innovation involves so called BIM Servers. They offer a central storage for a variety of building information. The centralized architecture potentially allows the stakeholders to access the data anytime from everywhere. The arising enhanced cooperation results in time saving and cost reduction.

The second innovation is the up-scaling of simulations in number and detail. It is desirable to simulate the effects of variations in construction elements on a building's behaviour during design stage in order to optimize the design as well as the final building. Due to hardware limitations most stakeholders involved in the architectural design competition and in the later bidding process are currently only capable of simulating a small number of variations. This increases the possibility of missing the best element selection for the given task and thereby also the risk to be defeated by counterparties.

Remedy is promised by the outsourcing of simulation jobs to powerful cloud computing resources.

Thus, it becomes possible to simulate the effects of a large number of variations in construction elements on a building's behaviour in a much shorter time frame. Not only does this increase the chance to excel counterparties. It also avoids costly subsequent revision.

Unfortunately, at the same time as both innovations save costs, they endanger the stakeholders' revenue and his and the client's intellectual property. Confident information, like for example the blueprints of bank or prison buildings, can easier fall into the wrong hands if they are stored on outsourced servers. In these cases contracts might make the outsourcing subject to conditions and restrictions. Counterparties getting access to the outsourced simulation data, gain information that help to undercut the offer, which means a considerable competitive advantage. Although this kind of espionage is illegal in most cases, it is hard to notice and even harder to prove.



Weighting benefits and drawbacks of outsourcing based on the example of a simplified IVEL framework architecture

Approach

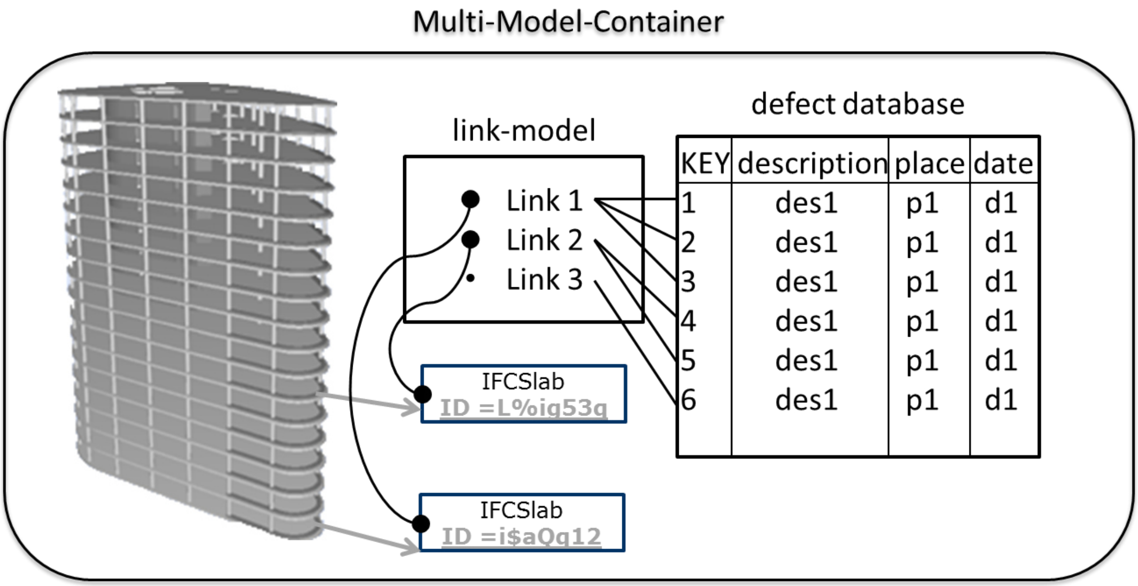
Initially both innovations have to be considered on a differentiated basis. Storage cloud and computing cloud solutions entail different risks which have to be analysed and categorized individually. The work is furthermore dedicated to the determination and the assessment of potential attack vectors as well as to the determination and elaboration of appropriate defence strategies. Stakeholders should be sensitised in order to be able to weigh the costs and benefits of outsourcing properly. They have to be provided with measures to protect their property and interests.

Multi Model Based Defect Management

Robert Kreil

Objectives

Because modern construction projects are getting more complex also the number of defects occurring during the construction phase is rising. This rising number of defects directly influences the construction costs. Also the bond of trust between customer and constructor is more stressed. Therefore the defect management should be more considered in site. The BIM technology brought a huge support for the building design in combining the geometric model with the costs model for example. But there is lack of support during the construction works. Neither the defect management nor the documentation of the construction is covered with existing BIM technologies. These two tasks offer a huge potential to reduce costs. Nowadays the whole defect management is done only in simple tables. This results in a big effort of time to overlook all the defects. By using modern BIM technology this process shall be simplified. Furthermore the handling of the software to realise the BIM based defect management has to be pretty simple and intuitive. For a better overview and the communication between all involved parties a visualisation is preferred.



Schematic description of the multi model container showing the links between domain models

Approach

The defects will be stored together with all relevant informations belonging to them like the place where it occurred, the time it occurred first, the responsible construction compony, etc. in a database with an input mask. The single elements of the database which are representing single defects will be linked to the single elements of the construction model by using the multi model method. This links can be created semi-automaticly by using the stored semantic informations. By using this technology the MMQL (Multi Model Query Language) can be applied to find specific defects i.e. all defects that belong to to certain construction stage and that have to be corrected by a specific construction company. Additionaly the results of the querry can be visualised in a 3D modell of the construction for a better orientation where to search while a construction inspection. Further on multiple defects can be marked as finished after an inspection. Which means that the amount of data for all defects becomes more usable. By using this method a huge amount of time can be saved during the construction phase with its numerous inspections by the construction companies and the building owners. Furthermore the costs for the defect management can be reduced and the bond of trust between the involved parties can be increased. A software which can process and link different model already has been developed and is named M2A2 (Multi Model Assembly and Analyzing Platform). This software has to be extended for the possibility of processing databases.

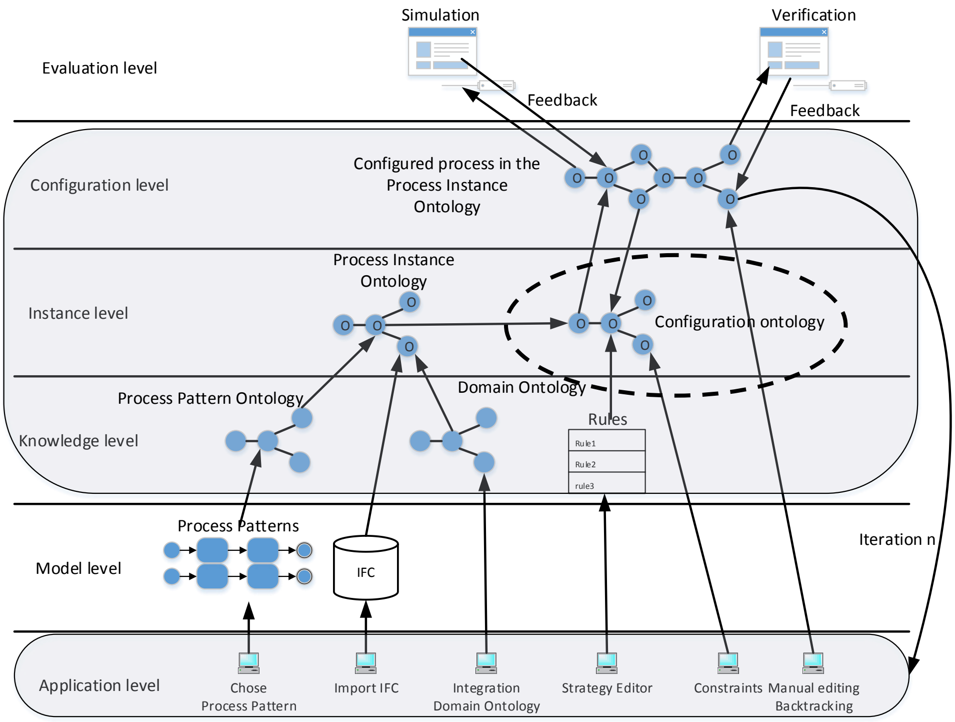
An Ontology for the Tracking of the Configuration Process

Alexander Benevolenskiy, Ksenia Roos

Objectives

The essential characteristics of the construction processes are the continuous flow of information and close communication between all participants involved in the construction project. The construction process model usually consists of many different data models, which can lead to difficulties in quick process configuration. The objective of this work is to analyse and classify different types of knowledge that influence the configuration process and to propose an approach for the logging and backtracking of the application of the configuration strategies. Different categories of knowledge can be derived from the definition of the configuration, from the configurator's requirements and from the analysis of the existing construction models. This includes technique, strategy, process, constraint, validation and configuration knowledge. For example strategic knowledge can be used for representing the construction strategies. And technique knowledge can formalize the process patterns, used for configuration. All the introduced types of knowledge are 1) related to each other 2) have its own representation formalism and 3) have an impact on the overall configured process.

This work is partially based on the methodology and concepts proposed and developed in some of our previous works about the ontology-based process configuration, but in this approach a special attention is given to the logging and backtracking mechanisms, which have not been considered before.



Configuration ontology in the general system structure

Approach

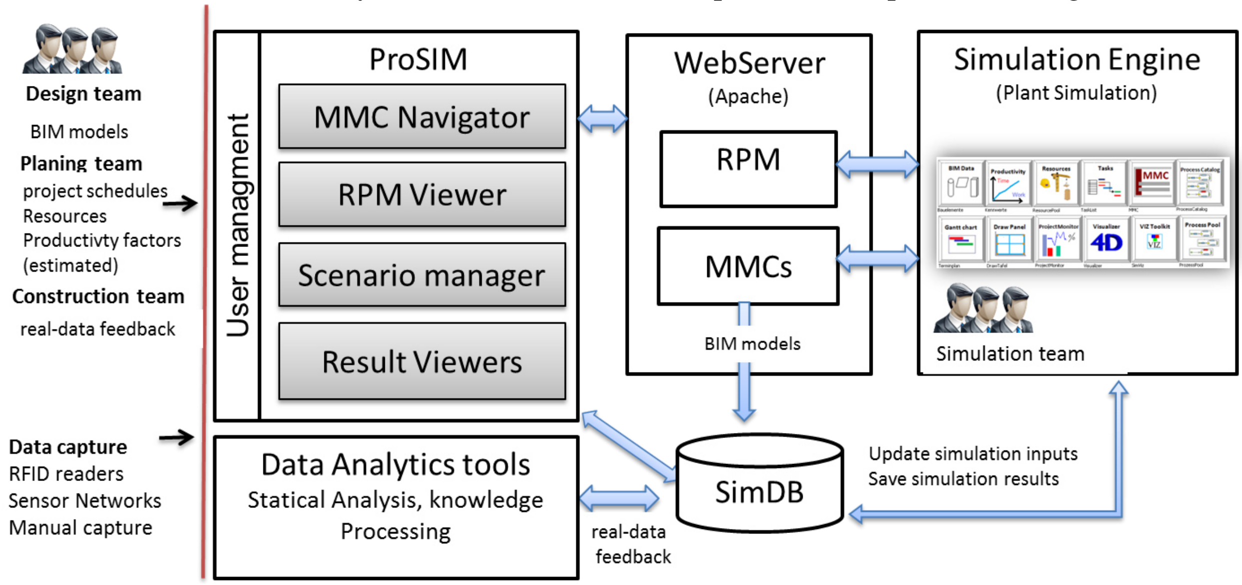
A particular interest of the current work is the configuration knowledge used for representing the configuration results. The configuration results can be saved as the knowledge about application of a certain construction strategy, and serve then as a log-file for analyzing, propagating or backtracking of these results. For that purpose a so called Configuration ontology is introduced. This ontology cannot only serve as a base for documenting the configuration knowledge in an understandable form, but provides functionalities to perform logging of all changes that are made during the configuration. During the application process the Configuration ontology is merged together with the Process Instance ontology and then rules are applied to this new merged ontology in order to generate new objects and save required logging information.

Improve the reliability of simulation results for construction project planning using real-time data collection, CPS principle and data mining methods

Ali Ismail, Yaseen Srewil

Objectives

Creating reliable simulation models to support the planning of big construction project is a very challenging task. The ongoing development of the Construction Simulation Toolkit (CST) aims to accelerate the task of creating simulation models based on formal reference process models, which describe the construction logic and include information about resource requirements and estimated productivity factors. As the construction project size grows the complexity and the amount of involved information which are necessary to create and validate the simulation models grow rapidly. For an effective application of simulation methods it is very important to develop real data collection systems in order to gather information and analyze events as they happen on the construction site during the construction phase. Cyber Physical System (CPS) approach can be a convenient solution; it enables an automatic collecting of various events and information at construction sites and links them to their digital models. These row data will be saved in a well-structured database and analyzed and evaluated with help of data and process mining methods.



Simulation platform extended with data capture interface and data analytical tools

Approach

The integrated simulation platform will be extended with a new module for data capturing and analytical tools. The aim of adding this module is continues improvement of simulation inputs and reference process models according to real data collected on the construction site. The data collection will include the following information and events: (a) delivery of building materials and installation steps of precast elements, (b) start, end and periodic progress of construction operations in addition to the real used resources to carry them out, (c) real utilization of human resources and construction machines. The real-time data collection aims to support project planning and simulation with accurate feedback during project execution phase. For this purpose a solution based on CPS/RFID technologies will be developed. This solution offers a mechanism for semi-automation data acquisition on construction site using cheaper passive RFID tags and sensor network. From collected and validated data the construction process progress can be derived and the estimated values of productivity factors can be revised, as well as necessary changes to reference process models can be applied. This leads to a more realistic and reliable results and improve the quality of construction project planning.

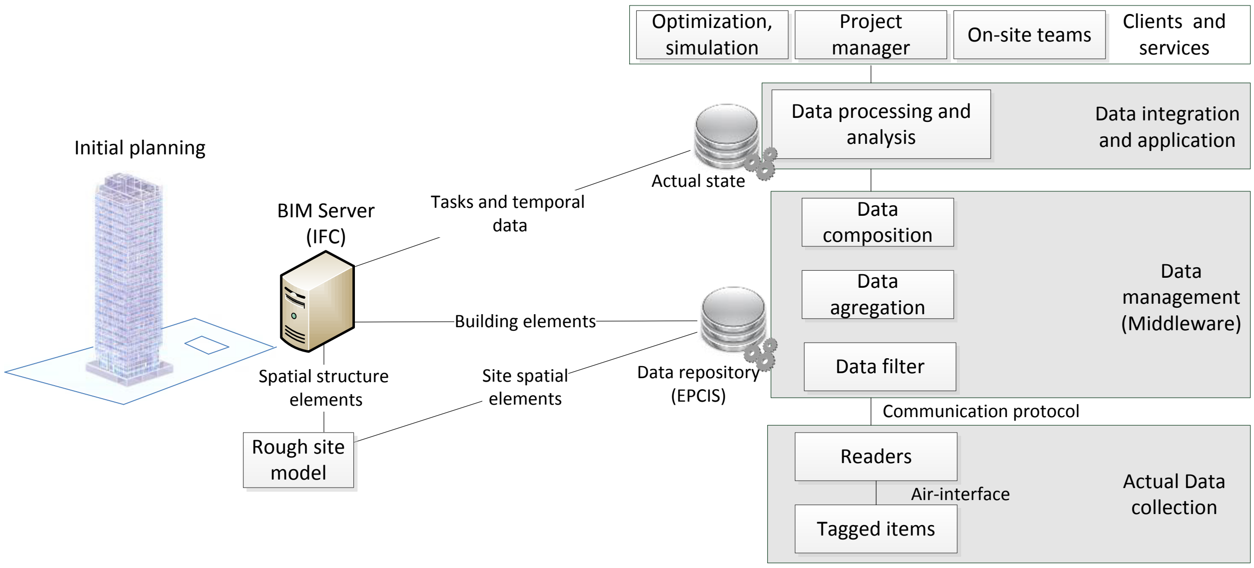
A framework for leveraging on site data acquisition using CPS principle

Yaseen Srewil

Objectives

Visibility and accuracy information exchange to the right place at the right time play a vital factor for the successful completion of a construction project. However, the efficiency of information management and keeping the data up-to-date are crucial and challenge tasks in construction industry. Also, there is a need for improving both the link between the construction site and project teams and the communication among those actors. The integration of the field, where the physical objects are processed, and the virtual models is necessary to enable an effective data capturing on-site. Moreover, it allows a continuous comparison of actual against planned performance and facilitates making decision. The advances in ICT-particularly sensing technologies- tackle these challenges and open the opportunities to achieve a "near" real time bi-directional coordination and integration between as-planned virtual models and as-is 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 mainly at project execution phase.

The focus here is to bridge the gap between physical constructions and their digital models. At this, a solution for effective on site data capturing and processing is introduced. This solution takes a distance from using of sensing technologies (i.e. RFID, GPS) as separate entities with their own features and limitation. It suggests a framework to accumulate and integrate site spatial information, tracked logistic business processes and the geographic location. Whereby, standard information can be coupled as fundamental for CPS principle.



A framework architecture for coupling physical object, construction site and digital models

Approach

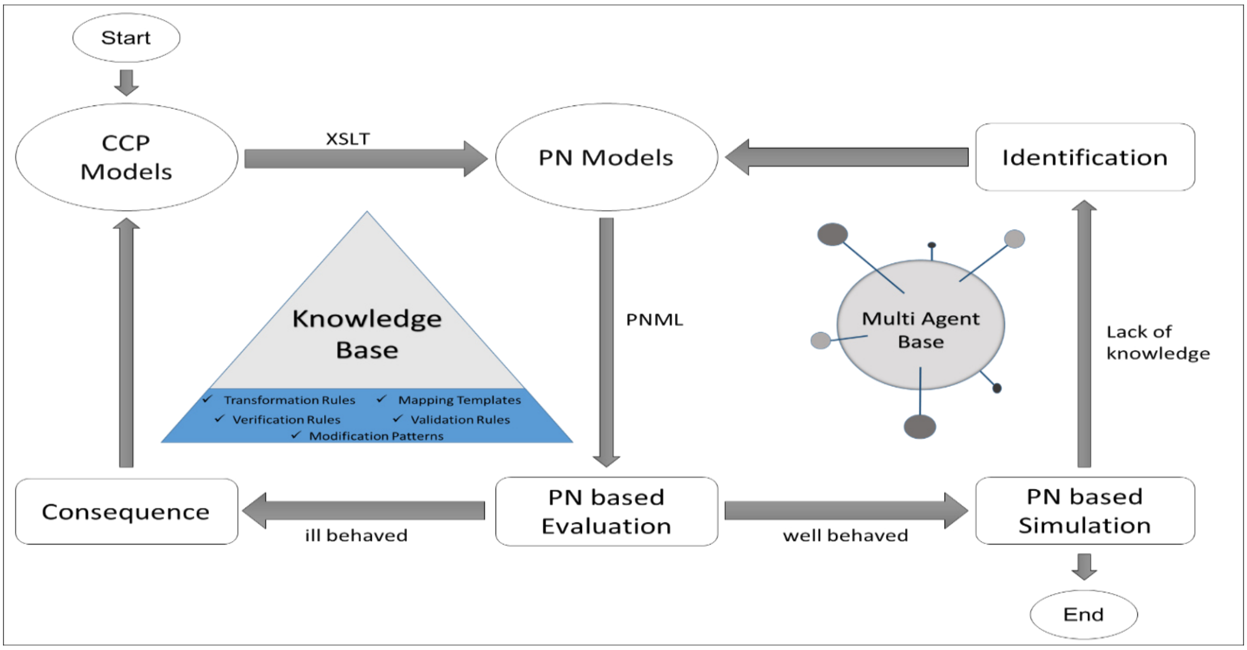
RFID technology is used usually to track objects and their business process. GPS identifies the geographical location of objects. The spatial structure element, building elements, and extended spatial defined construction site components give the context for RFID and GPS collected data. Here, rough site model elements will be defined partly using the spatial elements from Industry Foundation Classes (IFC) data model like *IfcSite, IfcBuilding, IfcSpace*. Further spatial information such as *work-zones laydown-areas* and *gate* is extended, which are necessary to identify the objects location and their business processes. At this, Electronic Product code (EPC) and its information services (EPCIS) standard is used to generate EPC-events. The spatial and building elements data add the needed semantic and business information to derive an object's state. Hence, continuous of physical construction objects states (in-, out construction site, is arrived, is stored, is mounted…) are stored to a well-structured database. The construction process progress can be derived using these aggregated and validated data including sensor error detection interpolation of sensor gaps, and therefore as-built data extracted. Finally this valuable information provides multiple services to the site teams about on-going activities and resources state, project manager to make decision on time and can be used for simulation and optimization purposes.

Petri Nets Based Verification and Simulation Approach of Semi-Automatic Configured Construction Processes

Faikcan Koğ

Objectives

Process configuration is a method to integrate various business process variants into a single model in order to eliminate redundant process parts and to bring flexibility to the modeled business process. However construction projects consist of very complex and detailed processes, which are not easy to model or to integrate with each other and to evaluate mathematically and graphically. Moreover 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. Therefore, process configuration should support not only process sequence variants, but should also support ad hoc changes in the construction process at all stages. In addition, configured processes should be supported by verification in order to identify and to avoid system errors like deadlocks, infinite loops, logical errors, etc. and to determine the model coherence according to the real world. 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) integrating the construction process simulation into the framework of construction process evaluation.



Petri Net based Configured Construction Process Verification and Simulation Approach

Approach

The main focus of this research is integrating the Petri Nets based simulation method to the knowledge base supported verification and validation approach of semi-automatic configured construction processes. The simulation model provides a convenient conditions to understand how projected operational scenarios are impacting the projects plan and design and appropriate capability evaluation for target requirements. Knowledge base consists of mapping templates, transformation rules, verification rules, validation rules and modification patterns. Petri Nets method, which is already selected for the evaluation and modification purpose, is also used to create simulation models. A java based process evaluation tool is designed in order to support automated XSLT transformation between BPMN and PN models, to validate and verify the initial models and to figure out the evaluation outputs in case of an ill behaved models. In this research well behaved models are handed over to the PN based Simulation tool. Resource allocation and scheduling are selected process levels in order to optimize the instance CCP models.

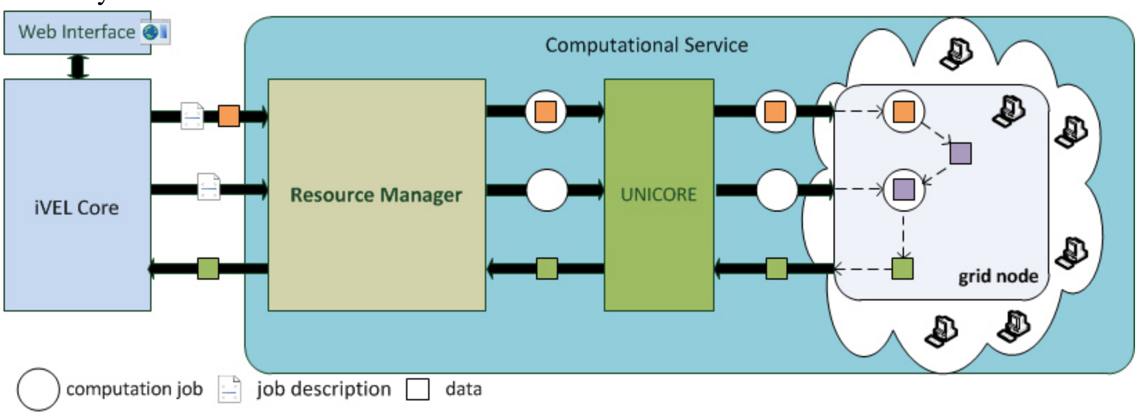
In further steps study will be enlarged with the identification of model in case of incomplete knowledge on structure, parameters or the algorithms of the system. Agent based systems are proposed to deal with this kind of unexpected behavioral or knowledge problems in simulation phase.

Advanced management methods for distributed computing of resource demanding civil engineering tasks

Michael Polter

Objectives

The concept of virtualization, which completely hides details about low level computing resources from the user and is the basic principle behind all conventional Distributed Computing (DC) management engines, emerges as a drawback when the degree of virtualization is not under user's control. For example most virtualization engines provide insufficient configuration possibilities in terms of data flow. Furthermore they lack of possibilities to define relations between jobs (e.g. data dependencies) and commonly treat computing tasks as self-contained black boxes. This constitutes as a problem particularly for civil engineering computations such as structural analyses which produce huge amounts of data that has to be transferred over the network in order to use it for post processing, e.g. simple filter operations. In such scenarios the network connection emerges as a bottleneck which frustrates the efficient use of the capabilities of Distributed Computing. Our goal is to enhance the current black box view of DC management engines in our virtual laboratory to their seamless usage as integrated components in order to extend the management possibilities for grid resources. This will help us to increase the performance of grid computations and decrease the necessary network traffic significantly.



Architecture of the Computational Service with extended management and scheduling capabilities

Approach

The *Computational Service* component, which represents the computation backend for the *iVEL*, currently uses the *UNICORE* grid framework to distribute computation tasks to arbitrary grid nodes and to transfer the result data back to the server. Thereby every computation job is treated as a distinct, self-contained unit which, once it has been sent to the grid, offers very limited monitoring options. For example, in order to apply post processing steps to the results of such a job, the usually huge amount of result data has to be transferred back to the central server, wrapped in a new job and then again sent to a grid node for execution. To overcome this bottleneck we look for new virtualization techniques which allow the definition of relations between jobs and their input-/output data. Therefore new approaches to enable application dependent job- and data distribution in the grid are investigated. A possible solution would be the aggregation of interdependent jobs in tasks which are transferred as a whole to a grid node and thus benefit from the principle of locality. Another conceivable approach is the provision of a workflow management system which allows the definition of temporal and data dependencies between jobs. Extended job description methods, which include information such as hard- and software requirements, are premise for more advanced job schedulers. To make these concepts available to the *iVEL* new grid scheduling- and resource management components have to be developed and integrated into the *Computational Service*.

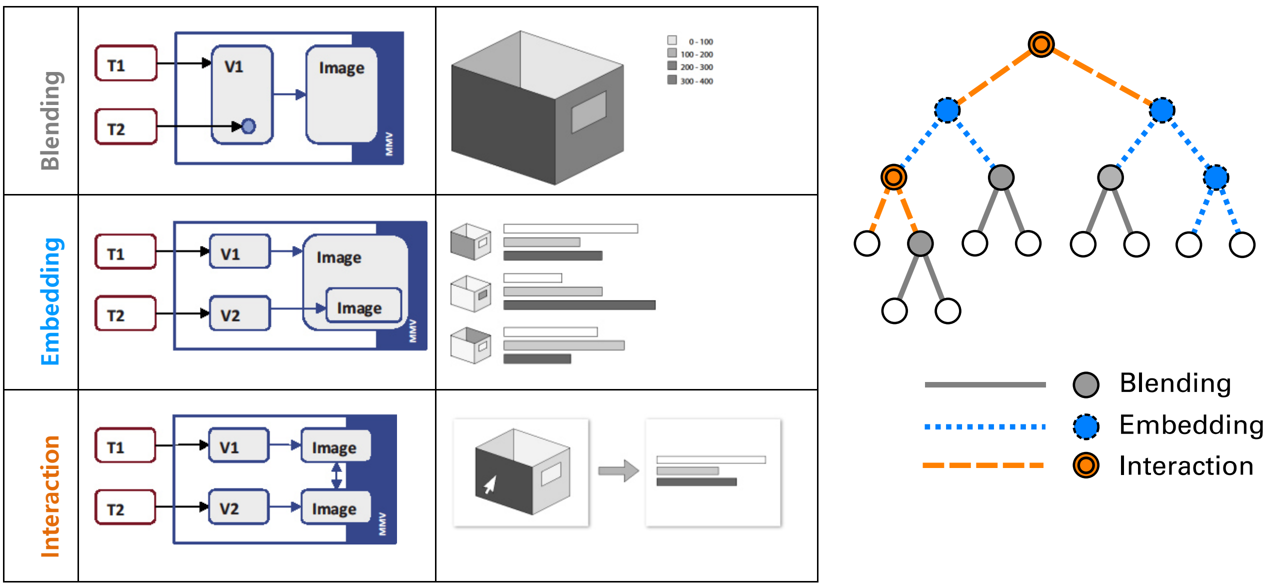
Specification of Complex Visualization Configurations Using Hierarchically Nested Mapping Rule Sets

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.

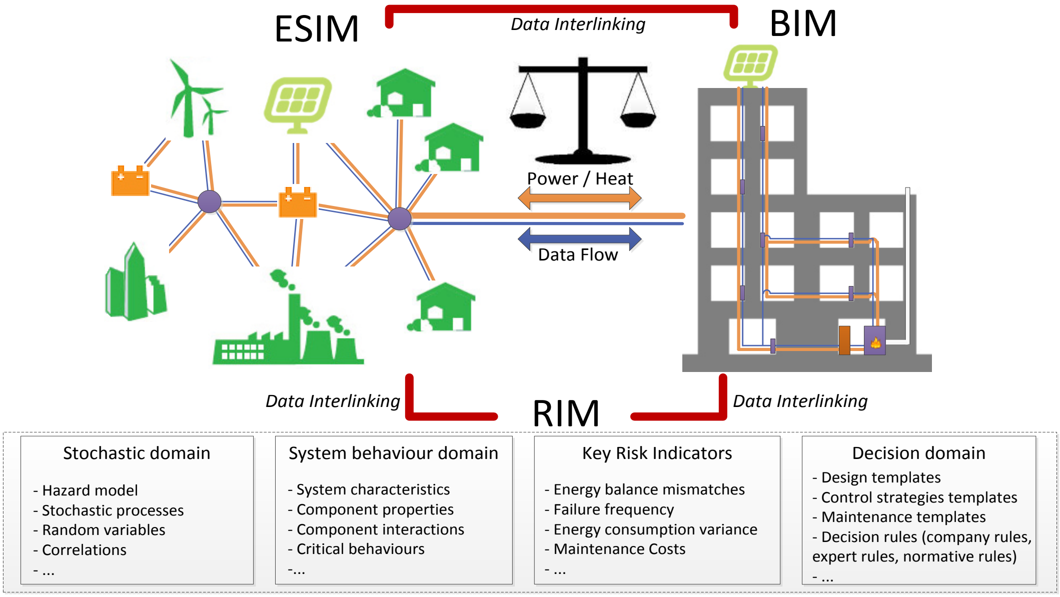
The framework will handle these different modes of visualization construction as well as their nested application. Thus, users of the framework are encouraged to organize their visualization descriptions in a hierarchical way. An analytical step preparing the following implementation has to answer questions 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.

Considering building performance uncertainty in energy efficient design

Hervé Pruvost

Objectives

Dealing with uncertainty in early building design is quite a challenging issue. Nowadays risk has become a very common concept in engineering but it is still a difficulty to assess them in a proper manner in order to make reliable estimations about the future lifecycle of the building. Most of time risk is associated with negative events and disadvantageous consequences. But more than that risk reflects the level of uncertainty that affects an activity. In energy efficient building design, this uncertainty relates to deviations of targeted performances because of the stochastic nature of the building. It can mean among others underperformance of a technological system, system vulnerability, lack of robustness or of compliance against guidelines. The different natures of risk share the same concepts around the overlying ones of uncertainty, effect, performance, correlation, causality and randomness as the international standard ISO 31000 about risk management shows. In view of that it becomes possible to formalize a risk data structure able to reflect several natures of risk as they appear in all building lifecycle phases.



Approach

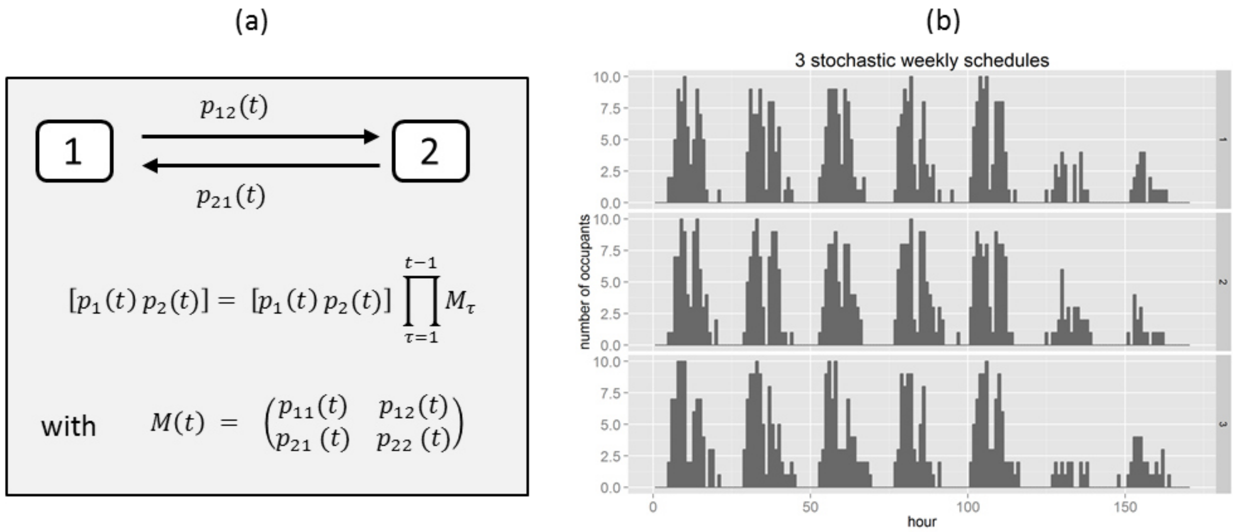
The uncertainty inherent to the building project can be considered in different manners and in different domains. To do so we introduce a Risk Information Model that interacts during the design process with the Building Information Model and the Energy System Information Model. To support that some aspects are of most importance like the kind of information modeled in the risk model and the interlinking strategies with external models. We introduce four main domains to support uncertainty-aware energy efficient design. The stochastic domain focuses on the mathematical representation of uncertainty e.g. setting a model as baseline for hazard analysis that contains required stochastic parameters. The system behaviour domain allows for a concrete description of the same uncertainty in the building and the interacting energy systems e.g. allowing to set hazard rates as component properties or to define critical behaviour scenarios. The Key Risk Indicators provide a quantification of uncertainty against the expected building performances. Those indicators are meant to be deduced from analyses and simulations relying on the two previous domains. The last domain is the decision one in which, on the basis of the actual simulated risk level expressed as indicators, the framework can support the designer in identifying proper planning options. Those planning options should reduce risk to a level that suits risk tolerances that can be expressed as stakeholder rules or as normative restrictions. The interlinking strategy results from the type of information considered. For example Key Risk Indicators can be seen as building properties, thus described as IFC Psets. For system critical behaviours there is a need for semantically richer links that allow for describing the kind of interaction between components. For that purpose the use of predicates enabled by RDF/OWL based ontology modeling is of most interest.

Occupancy modeling using inhomogeneous Markov chains

Frank Noack

Objectives

Occupancy is one of the key variables that need to be monitored in achieving reliable simulation of energy consumption in buildings. Occupants interact with the indoor environment through heat and carbon dioxide emission, switching light on/off, opening windows, will heat or cool their environment etc. As an input to other models occupant presence will be central to the family of stochastic models describing several means of interaction. Because of the heavily uncertain nature of occupancy dynamics, the construction of mathematical models that are appropriate for real time estimation is a challenging problem. The usage of a non-homogenious Markov chain as an agent-based approach allows the generation of suitable stochastic occupancy patterns which can be integrated in building simulation workflows.



Markov chain occupancy model for two states (probability of presence in a given state and transition probabilities (a) and three examples of simulated weekly occupant presence for an office room with a capacity of ten people (b).

Approach

The outlined model predicts simply whether each occupant is present within a particular zone or not, whereas the movement of occupants from one zone to the other is not considered hitherto. The underlying hypothesis is that the probability of presence at a time step $p_i(t)$ only depends on the state of presence at the previous time step[1] which corresponds to considering the state of occupancy as a Markov chain with probabilities of transition $p_{ij}(t)$ (Figure). The values of $p_{ij}(t)$ have to be time dependent representing the general case of an inhomogeneous Markov process with discrete states and discrete time steps respectively. Furthermore the hypothesis of independence makes it possible to simulate the patterns of presence of each occupant individually. Given a complete set of transition probabilities, a realization for one person can be made by assuming an initial state, generating a uniform random number in each time step and comparing this with the transition probabilities to determine which transition is taking place. The number of persons n out of N occupying a certain state i could be estimated by simulating each occupant separately and then adding the produced pattern. Otherwise since all realizations are independent, the probability that $n_i(t)$ equals a given number n depends on the possible combinations of N realizations, each occupying the state with a probability $p_i(t)$, that satisfy $n_i(t) = n$. Hence, $n_i(t)$ should be binomially distributed and the number of persons can be estimated using:

$$Prob(n_i(t) = n) = \frac{N!}{n!(N-n)!}\, p_i(t)^n \big(1 - p_i(t)\big)^{N-n}.$$

In this way it is possible to create reliable occupant presence sequences as illustrated in the figure.

[1] Markov condition

Aspects of Stochastic Simulation

Tom Grille

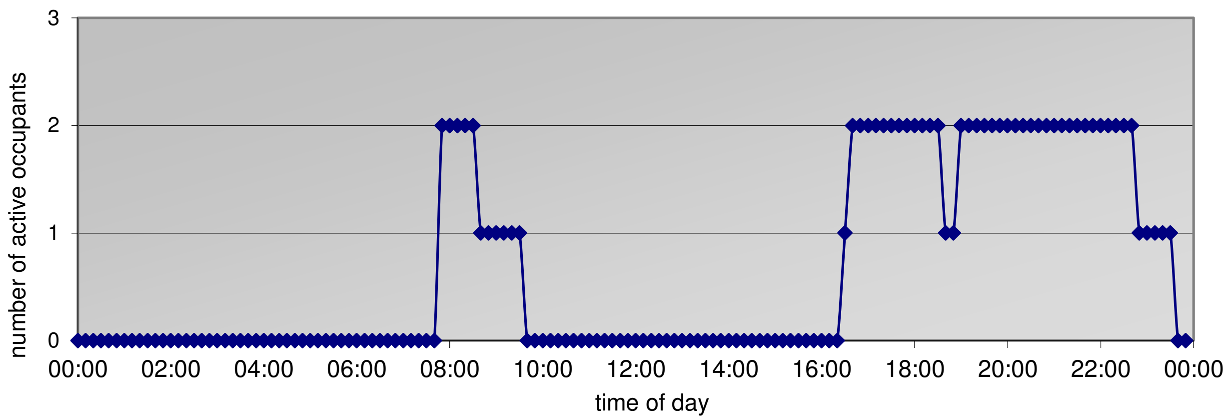
Objectives

In a large-scale project such as the construction of a building, a high amount of information is only available in a probabilistic manner. Stochastic techniques need to be applied to make the best use of such uncertain information.

In this research, the focus is on two specific topics: Occupancy simulation and sensitivity analysis.

Occupancy: To predict the future energy demand of a building, one has to consider its usage, and thus the people who interact with it. For example, there first needs to be a proper simulation of the manual usage of light switches before one can use simulations to compare it to other strategies like automatic lighting. Other important occupancy driven factors include ventilation and the use of blinds or electric devices such as computers or coffee machines.

Sensitivity: When studying large and complex models with various inputs, it is often desirable to quantify the impact each input has on the output(s). For a linear model with independent inputs simple derivatives are sufficient, yet these assumptions rarely hold in reality. Thus, more complex techniques are needed to approach nonlinear models with correlated inputs.



Example of a simulation of the number of active occupants in a two-person household during a work day

Approach

Occupancy: Occupancy based energy simulations are trifold. Firstly, one needs to simulate the number of active persons in any given zone at any time. Secondly, their interactions with the devices in these zones need to be simulated. The third part includes the ordinary energy calculations, taking into account the information generated in the previous steps. The basic tool for this kind of simulation is the inhomogeneous markov chain of first order. This stochastic process allows the definition of so-called transition probabilities, e. g. the probability of a person using a device, or leaving or entering a zone. A major problem is how to obtain the numerical values of these probabilities. Only field studies can provide accurate numbers and help increase the precision of occupancy simulations.

Sensitivity: Let the input variables be $x_1, x_2, \dots, x_n$, the output be y and the model be an unknown function f, so we can say $y = f(x_1, \dots, x_n)$. A common approach to quantify the impact of each input is to study the proportion of the output's variance it causes. This is done by means of the so-called correlation ratio ϑ. Let x' be a subset of $x_1, \dots, x_n$. Then the relative contribution of x' to $V(y)$ is defined as

$$\vartheta_{x'} := \frac{V[E(y|x')]}{V(y)},$$

where $E(y|x')$ denotes the conditional expectation of y given x'.

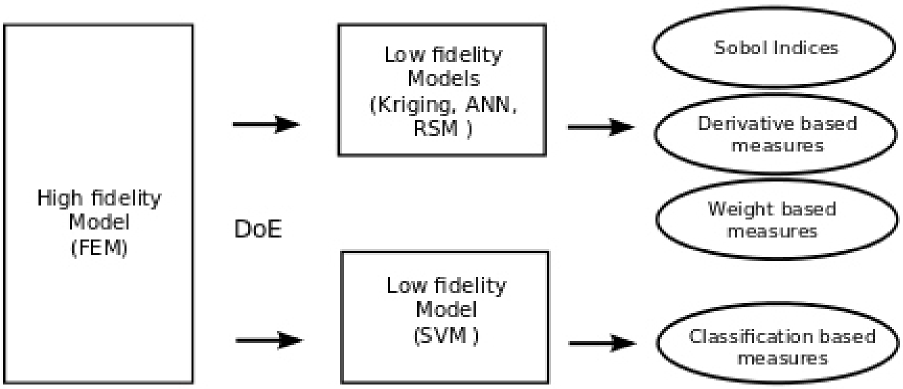
When the x_i are correlated, an otherwise meaningless input with a high correlation to an impactful input will be assigned a high correlation ratio. Further techniques need to be applied to recognize this kind of contribution.

Non-linear global sensitivity measures for an efficient 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) helps 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.

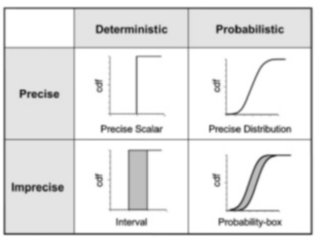
Complexity reduction of imprecise structural systems based on probability box concept

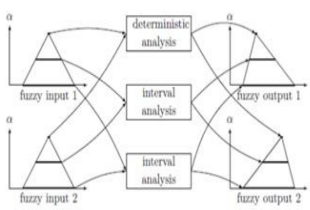
Jamshid Karami

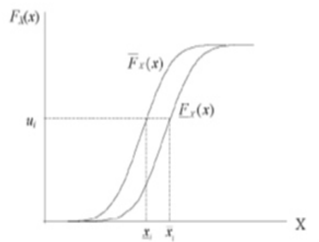
Objectives

Nondeterministic Finite Element Methods (FEM) such as Interval, Fuzzy and Probability Bounds has gained more attention in recent years. Among them the Probability Bounds Analysis (PBA) is an expressive generalization of both traditional probability distributions and interval representations, actually it incorporates both imprecision and probabilistic characterizations by expressing interval bounds on the cumulative probability distribution function of a random variable. Monte Carlo simulation (MSc) is popular and well developed to Finite Element Analysis (FEA) of structures with imprecise variables. In this approach, the samples on probability boxes result interval samples that leads to interval FEA (IFEA) of structures. In addition to improve accuracy of computation the Quasi Monte Carlo simulation (QMCs) with deterministic low-discrepancy sequences is used to generate samples. Finally the lower and upper bounds of probability of failure in each simulation and then the p-box of failure can be computed.

Although such new procedures offer much more realistic approach for analysis, the utilization of these methods in practical applications remains limited due to less attention to develop necessary software for analysis as well as the computational efforts that are much more than deterministic analysis. Therefore, performing reliability analysis, leads to impractical computational costs especially for complex models. There are also many limitations in current methods. They do not guarantee to bounds the true response ranges and the results tend to be excessively conservative with the increase of problem complexity. Therefore, there is a need for a computationally efficient method that is capable of accounting for uncertain parameters and yielding rigorous and sharp bounds on the ranges of the structural responses.







$$\begin{cases} \underline{P}_f = \dfrac{1}{n}\sum_{j=1}^{n} I[\overline{g}_j(X) \leq 0] \\ \overline{P}_f = \dfrac{1}{n}\sum_{j=1}^{n} I[\underline{g}_j(X) \leq 0] \end{cases}$$

Approach

Developing a new procedure for sampling is one of the most important parts of research. The goal is establishing an efficient procedure to reduce the number of necessary Finite Element Analysis to reach a reasonable accuracy. Thus the samples are generated based on low-discrepancy sequences. Definition a suitable measure for describing damage in the structure or a suitable limit state function is the next phase of the research. Representation a procedure to reliability analysis under imprecise seismic loads presented as p-boxes is another main step of research.

Definition an algorithm to IFEA of structures based on interval arithmetic is the most important part of this research. The proposed method should be able to manage overestimation, coupling and dependency in interval computation in each time step of proposed method. A Finite Element code will be developed to perform PBA and reliability analysis.

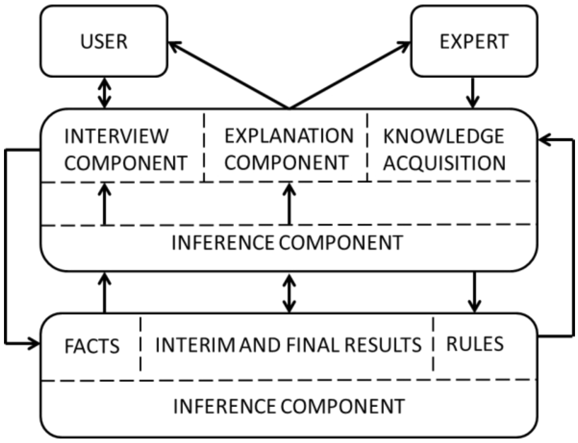
Then by means of case studies the efficiency of proposed method will be verified. Numerical analyses will be performed using developed Interval Finite Element code. For this purpose the specifications of Steel moment frames as the target group of structures, including their material properties and seismic loads will be defined as p-boxes. In this phase the results of previous stages of current research are used as a guideline to select the appropriate input parameters. Based on results a methodology will be proposed to reduction the complexity of IFEA of structural systems under seismic excitation.

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.

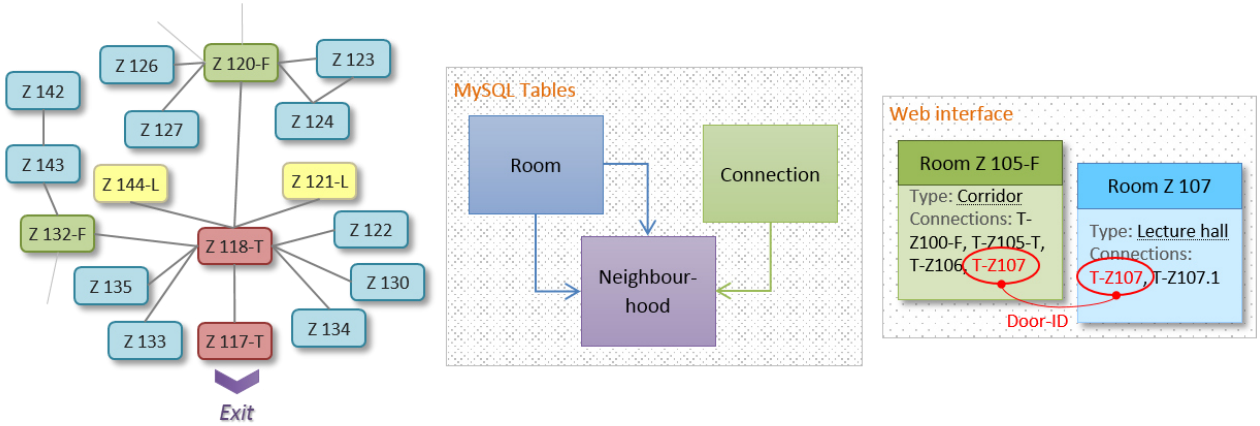
1) Co-operative PhD thesis with the University of Applied Sciences Dresden, supervised by Prof. Undine Kunze.

Graph-Based Navigation in a 3D Campus Infrastructure Model

Hermin Kantardshieffa

Objectives

Modern navigation systems based on LBS (Location Based Services) and GIS (Geographic Information Systems) provide an individual with information on position and aid with guidance. From a functional point of view, navigation includes two separate tasks: localization and guidance. The localization is a method to obtain the position of an object in a defined referential area. The guidance is used for real-time interactions with the drivers of a vehicle (boat, car, and airplane) or with a pedestrian via voice, maps or symbolic representation. It includes the computation of the shortest or fastest way to go from the current point to the desired one and the communication to a person. An infrastructure model represents the virtual and interactive 3D visualization of a set of associated buildings that exist in the real world such as university campuses. The virtual three-dimensional model of a complex campus infrastructure allows various navigational methods. The most important aim of a virtual navigation for the user is the Indoor (or In-Building) navigation. The goal of the proposed graph-based navigation within the scope of a research project ISCID[1] is the development of efficient methods for the calculation of the shortest and optimum path between two topological spaces as rooms in a three-dimensional building infrastructure model.



A coloured graph of a campus building and a MySQL database are required for a web-based campus navigation

Approach

The navigational tasks of routing (i.e., route planning) and guidance are theoretically based on graph theory rules. In order to describe the matter of Indoor navigation visually a graph model is used. Each campus building is represented as a non-directional connected graph $G = (V, E)$ with $V = \{ v_1, v_2, v_3, \ldots, v_k \}$ as a vertex set representing the rooms and $E = \{ e_1, e_2, e_3, \ldots, e_n \}$ as an edge set representing the doors, where k is the total number of the rooms and n is the total number of the doors. The vertex set V consists of four different vertex classes that form the graph G as a coloured graph with $S = \{$ blue, green, red, yellow $\}$ as a colour set. All structural components of the building graph – the vertices and the edges – are stored as unique data sets in a relational MySQL database. Since rooms are connected to their neighbour-rooms via unique door connections, a double one-to-many-relationship between tables is used. The degree of each vertex describes the maximum amount of possible connections for a specific room to other neighbour-rooms. Since $V \leq E$ and each room has at least one door connection, it is essential to consider the correlation $\frac{E}{V} \geq 1$ in order to precisely calculate the shortest paths between given start and end positions within a building. The two-way routing paths are obtained by using a shortest-path algorithm such as Dijkstra's. The routing decisions are based on topology information (i.e., neighbouring nodes). A web-based navigational method "Connection Search" is used to calculate the nearest connection (i.e. entrance) to the next adjacent room. Some rooms like foyers, corridors and stairways have more than one connection. On the web interface and according to the floor plan, each room-to-neighbour-room-connection is represented as a PHP-generated link labelled with the corresponding door identification.

---

[1] 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:	**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:	3.3 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 inter-operability. 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:

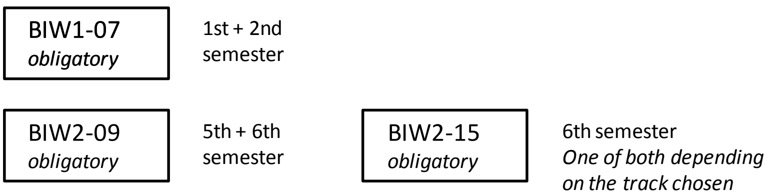
Interessengemeinschaft des Heinz-Piest-Instituts an der Leibniz-Universität Hannover e.V. – **Coordinator**,
AEC3 Deutschland GmbH (München),
Dachdeckermeister Claus Dittrich GmbH & Co KG (Dresden),
Handwerkskammer Koblenz,
Handwerkskammer Münster,
Zentralstelle für die Weiterbildung im Handwerk Düsseldorf,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

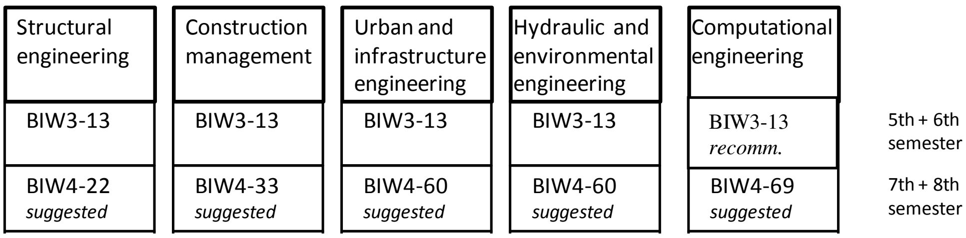
Lecture Activities

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/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 preparatory 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/Opitz

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

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, Kreil

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 7th semester up)
Lectures and Tutorials:	Scherer/Katranuschkov, Kreil

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, Nityantoro

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 2014

[1] MOSCH M., GROß S., SCHILL A.: User-controlled resource management in federated clouds. In: Journal of Cloud Computing: Advances, Systems and Applications, Vol. 3, No. 1, 2014.

[2] KOG, F., DIKBAS, A., SCHERER, R.J., Verification and Validation Approach of BPMN Represented Construction Processes, in: Proc. of Creative Construction Conference 2014, Prague, Czech Republic, June 2014.

[3] OPITZ F., WINDISCH R. & SCHERER R.: Integration of document- and model-based building information for project management support, In: Proc. Creative Construction Conference 2014 (CCC2014), Prague, Czech Republic, June 2014.

[4] POLTER M., ISMAIL A. & SCHERER R. J.: An integrated grid-based web platform for advanced structural design and analysis, In: Proc. Creative Construction Conference 2014 (CCC2014), Prague, Czech Republic, June 2014.

[5] KADOLSKY M., BAUMGÄRTEL K. & SCHERER R.J.: An Ontology Framework for Rule-Based Inspection of eeBIM-Systems, In: Proc. Creative Construction Conference 2014 (CCC2014), Prague, Czech Republic, June 2014.

[6] POLTER M., ISMAIL A. & SCHERER R. J.: Towards an integrated grid- and cloud-based Structural Analysis Platform, In: Proc. International Conference for Computing in Civil and Building Engineering 2014 (ICCCBE2014), Orlando, Florida, United States, June 2014.

[7] ROOS K., BENEVOLENSKIY A., SCHERER R.J.,: Towards knowledge-based Process Configuration in Construction, In: Proc. EG-ICE Workshop 2014, UK, Cardiff, July 2014.

[8] OPITZ F.: Integration von dokument- und modell-basierten Informationen zur Projektmanagementunterstützung, In: Proc. Forum Bauinformatik 2014, Darmstadt, Germany, September 2014.

[9] TAUSCHER H., SCHERER R.J.: Use cases for configurable building information model visualization. In: Fusion (ECAADe 32), Newcastle, UK, September 2014.

[10] TAUSCHER H., SCHERER R.J: Specification of complex visualization configurations using hierarchically nested mapping rule sets. In: Proc. 10th European Conference on Product and Process Modelling (ECPPM), Vienna, Austria, September 2014.

[11] SCHERER R.J., GURUZ R., CALLEJA-RODRIGUEZ, G., GEISSLER, M.-C: Towards a KPI-controlled holistic design method for eeBuildings, In: Proc. 10th European Conference on Product and Process Modelling (ECPPM) 2014, Austria, Vienna, September 2014.

[12] ROBERT, S., MAZZA, D., MEDIAVILLA INTXAUSTI, A., GUIGOU, C., MARTIN, J., PRUVOST, H., SCHERER, R., FERRANDO, C., DELPONTE, E.: The HOLISTEEC platform for building design optimization: an overview, In: Proc. 10th European Conference on Product and Process Modelling (ECPPM) 2014, Austria, Vienna, September 2014.

[13] BAUMGÄRTEL K., KADOLSKY M. & SCHERER R.J.: An ontology framework for improving building energy performance by utilizing energy saving regulations. In: 10th European Conference on Product and Process Modelling (ECPPM). Vienna, Austria, September 2014.

[14] GEISSLER, M.-C., van WOUDENBERG, W., GURUZ R., CALLEJA-RODRIGUEZ, G.: Processes and requirements for an eeEmbedded virtual design laboratory, In: Proc. 10th European Conference on Product and Process Modelling (ECPPM) 2014, Austria, Vienna, September 2014.

[15] BASSANINO M., FERNANDO T., MASIOR J., KADOLSKY M., SCHERER R.J. & AL.: Collaborative environment for energy-efficient buildings at an early design stage, In: Proc. 10th European Conference on Product and Process Modelling (ECPPM). Vienna, Austria, September 2014.

[16] ISMAIL A., SCHERER R.J.: Integration of Simulation Data for Construction Project Planning Using a Process Based Simulation Framework. Proc. 13th International Conference on Modeling and Applied Simulation, MAS 2014, Bordeaux, France, September 2014.

[17] GURUZ R., SCHERER R.J.: Building Requirements as Basis for a Key Point controlled Design Method, In: Proc. European Commission: Sustainable Places 2014, France, Nice, October 2014.

[18] MOSCH, M.: Ensuring Data Sovereignty in the Cloud – Service Management for Cloud Resources, PhD thesis, Dresden, Germany, October 2014.

[19] ISMAIL A., SREWIL Y., SCHERER R.J.: Collaborative Web-based Simulation Platform for Construction Project Planning. In: Camarinha-Matos L., Afsarmanesh H. (ed.): Collaborative System for Smart Networked Environments. PRO-VE 2014, pp. 471-480, Springer Verlag, October 2014.

[20] OPITZ F. & SCHERER R., Wie entsteht ein BIM Modell? In: Proc. Fachkonferenz Bauinformatik – Baupraxis, BIM für das Handwerk, Dresden, Germany, December 2014.

[21] GÜRTLER, M. & SCHERER, R., Gezielte Informationsabfrage mit BIMcraft, In: Proc. Fachkonferenz Bauinformatik – Baupraxis, BIM für das Handwerk, Dresden, Germany, December 2014.

[22] KREIL R, SCHERER R. J.: Informationslinkerstellung und -validierung In: Proc. Fachkonferenz Bauinformatik – Baupraxis, BIM für das Handwerk, Dresden, Germany, December 2014.

Positions in Editorial Boards of Journals

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	Member.
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.