TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUT FÜR BAUINFORMATIK

PROF. RAIMAR J. SCHERER

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RESEARCH AND LECTURE ACTIVITIES IN 2010

December 2009

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, i.e. to new ideas and what is planned in 2010, based on the results achieved in 2009. Current research topics are: (1) building information models, (2) intelligent engineering structures and construction methods, (3) virtual organizations, (4) project risk and simulation management, (5) dynamic process modelling and (6) e-learning. Major methods applied are object-oriented modelling and management, engineering and business ontologies, description logic, service-oriented architectures, grid computing, fuzzy logic, stochastics and information mining.

2009 has been the most successful year of the institute. In March, a 3-year German lead project in construction informatics started with 12 partners, co-ordinated by the institute, and in July, the 4-year EU integrated project Trans-IND was inaugurated. These projects mean 9 research positions for the institute. In December, the 3-year EU project SARA with 2 research positions was finally approved by the commission and will start in 2010. In November, the 3-year German proposal eWork Bau, an e-learning project on model-based work on the construction site focusing on the integration of handicraft workers, was approved with another 2 research positions and is open for negotiations. This success in research project acquisition enables the institute to broaden its natural basis, namely product modelling methods and extends it to other challenging areas like process modelling and simulations, applying informatics methods from artificial intelligence, Web 2.0 technology, distributed databases and ontologies.

The institute strongly promotes IT in research and industry. Prof. Scherer is chairman of the European Association of Product and Process Modelling, which will hold its 8th ECPPM conference at the University College Cork, Ireland from 14th to 16th September 2010. In early September 2008, the conference again brought together leading European academic and industrial researchers and developers in construction IT and BIM working groups in Nice, France (*http://www.ecppm.org*).

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

The “Dresdner Bauinformatik-Gesprächskreis” (Dresden Construction Informatics Roundtable) was silent in 2009 due to the new projects that had to be quickly structured and started but will be reactivated in 2010. Presentations are available at *http://cib.bau.tu-dresden.de/ddbig*.

E-learning activities have been continued. The developed innovative interactive construction site simulator was further extended towards virtualization and integrated in BlueJ. With the newly acquired project eWork Bau a valuable acceleration in e-learning is expected in the next years. The European on-line master course “IT in Construction”, co-ordinated by the University of Maribor, Slovenia, is now in its 6th academic year and students can be enrolled in 7 European universities. Lectures on applications of ICT to improve energy efficiency of buildings have been developing in the REEB project.

Collaborative research continued on somewhat lower level due to the heavy work load on the new research projects. In 2009, Prof. Scherer stayed with Prof. Attila Dikbas at the Istanbul Technical University for about 10 days and new collaboration has been prepared with the University of Applied Sciences of Northwest Switzerland (Prof. Breit and Prof. Häupi), the University of British Columbia Vancouver, Canada (Prof. Froese) and the Stanford University, USA (Prof. Fischer).

Many personal changes have happened in 2009. In October, Alexander Gehre left the institute to found his own company together with Dr.-Ing. Matthias Weise, a former co-worker of the institute. His PhD is nearly finished and will be submitted in early 2010. Between May and October, several new researchers joined the institute, namely Michael Baling (with a degree in business informatics), Romina Kühn and Ulrike Schirwitz (multi-media informatics), Alexander Benevolenskiy (theoretical informatics), Thomas Eisenreich (architecture) and Ali Ismail (civil engineering). Several PhD students like Sven-Eric Schapke, Wael Sharmak and Amin Zahedi (civil engineering) and Faikcan Kog (mathematics) changed their positions to researchers. The institute staff now covers a broad range of expert domains and is multi-lingual, with researchers from Bulgaria, Iran, Peru, Russia, Syria and Turkey.

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

Dresden, in December 2009 Raimar J. Scherer

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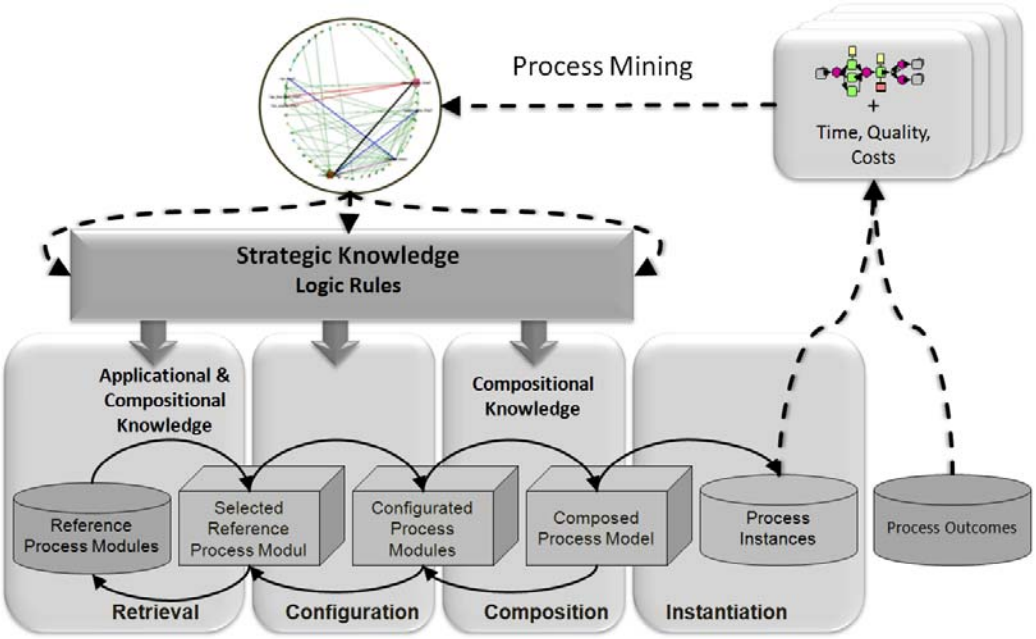
Explication of strategic process-related knowledge based on empirical data

Michael Baling

Objectives

The building industry partly suffers from a weak design of the construction processes. Indeed available formalisation and reengineering approaches from the stationary industries cannot be easily adopted because the one-of-a-kind character of construction projects entails high flexibility and adaptability. Latest academic efforts that have led to the development of configurable sub-processes appear to be more suitable. Application of such sub-processes is achieved by means of *reusable reference process modules* as developed in the project BauVOGrid. To support the optimal generation of overall processes the process modules have to be enhanced with functional process-related knowledge. Hence, in addition to the knowledge about the combinability and configurability of the process modules, i.e. application and compositional knowledge a superior *strategic level of knowledge* is needed to determine which of the possible process combinations should be preferred in a particular context. This knowledge about designing successful processes dependent to the project background is already contained in the mass of cases previously developed by experts. Explicating and formalising this latent knowledge by upgrading the reusable process modules to *knowledge modules* will allow the intelligent automated creation of design recommendations. In this manner an iterative improvement of the assistance for designing construction processes is achieved.



Explication of strategic process-related knowledge based on process mining

Approach

One possibility to formalise and store strategic process information is to create logic rules. These rules about choosing the optimal sequence will be gathered by evaluating the already used process instances via statistical methods known from the process mining methodology. To differentiate efficient process sequences from less successful configurations each case has to be mapped to his outcomes. Likewise to ensure that only suitable cases are investigated the context of the case has to be regarded. For discovering interesting patterns and distinctions in the event sequence methods dedicated to the *case perspective of process mining* are applied. They deal with analysing the process path of a larger amount of cases. The recognised process patterns are mapped to key performance indicators for quality, time and costs by an *association analysis* to generate and evaluate rules for different levels of detail in the design of the overall processes. This approach is illustrated in the figure above.

Processes designed by incorporating the rules also have to be related to their outcomes after accomplishing to check the correctness of the assistance. Shortcomings have to be analysed and managed before using the new cases as input again. By this post processing a permanent adaption and enhancement of the process models is realized which limits autocorrelation. This obtains an iterative process optimisation based on empirical data. Given the rules forming the strategic knowledge different possibilities for formalisation and enhancing of the reference process modules will be investigated within the MEFISTO project.

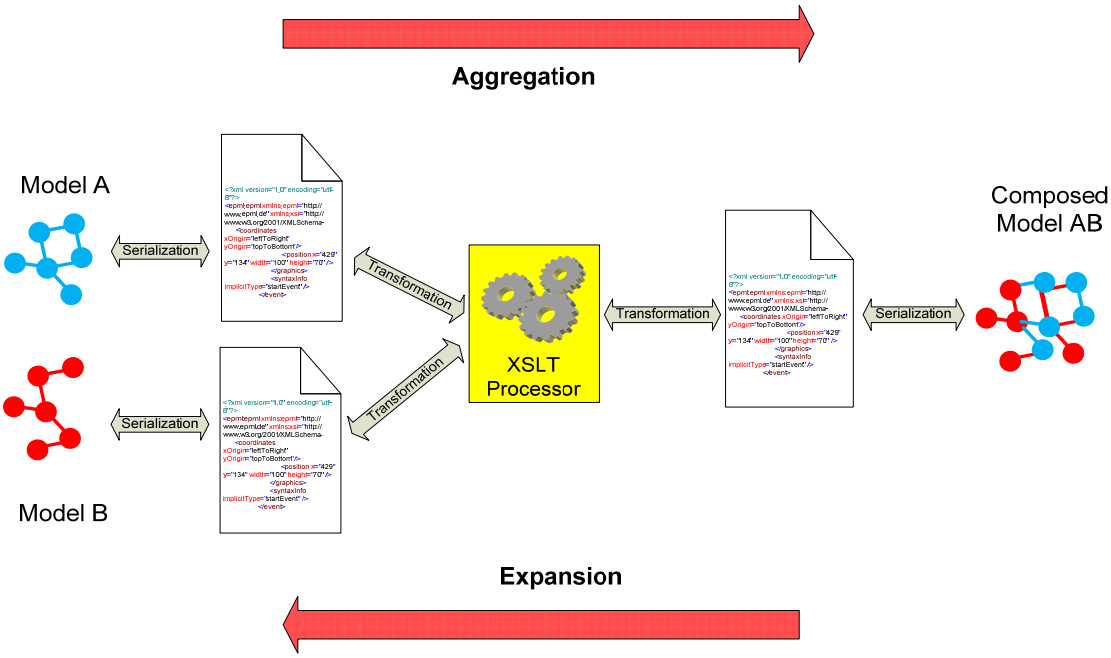
Enabling Model Transformations on Different Abstraction Levels Using XSLT

Alexander Benevolenskiy

Objectives

Modeling is an essential approach to represent a complex system or process on more abstract level. Models provide a simplified abstract view of reality and therefore are widely used in many industrial applications. In AEC multiple models are typically used to support the construction process. Such models include building information, site information, material resources and equipment, processes, costs etc. Moreover, the overall construction process is managed on different levels and on each of these levels specific model views on different levels of abstraction have to be considered. Hence, it is a challenging problem how to go from one level to another, maintaining relevant decision-making information. For this purpose a proper transformation mechanism is needed.

In our current assumption a formal description of the models can be realised by ontologies, which are serialised using RDF/XML syntax. Therefore an appropriate transformation technique of serialised models in the form of data files or documents is to be found.



Models transformation by using XSLT

Approach

The proposed solution for the described problem is to use *EXtensible Stylesheet Language Transformation (XSLT)*. XSLT is an XML-based language widely used for the transformation of XML documents. It allows using many of the basic mapping patterns identified in earlier research studies at the institute. The possibility of having multiple source objects as input allows to realize *N:1* mappings, where a new object is obtained from several other objects by combining them according to some specific transformation rules (*Aggregation*). *1:N* mapping is similarly possible, with the support of the output to multiple objects (*Expansion*). For more complex mappings, custom stylesheet functions can be developed, or Java code can be integrated into the stylesheet.

XSLT is a specialized transformation language but not a full general-purpose language and therefore there are many issues that are out of its scope. Therefore, extensions of the language will also be investigated as part of the research, in order to support use of mathematical functions and logical operations in the inter-model transformations.

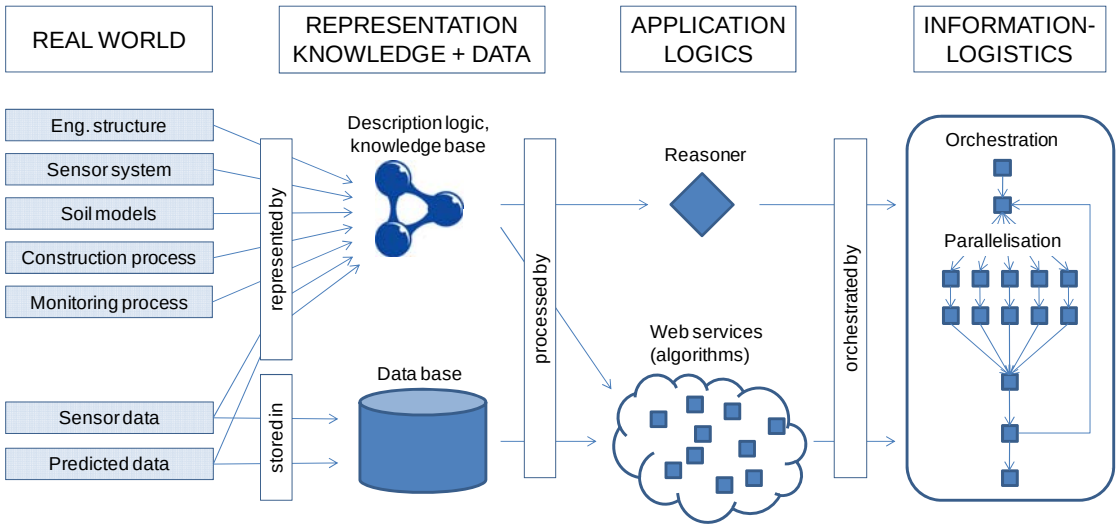
The results of the work, performed in the frames of the German lead project MEFISTO, will enable various transitions between different modelling levels, thereby providing for the use of most suitable views on the data for decision makers on different required levels.

Integrating Databases and Description Logics as Part of a Monitoring and Control System for Geotechnical Engineering Structures

Gerald Faschingbauer

Objectives

The main objective of this work is the realization of adaptive production methods through application of Web 2.0 technologies. The flexible, demand-oriented integration of knowledge bases and data bases, web services for simulation and analysis as well as computing resources and consulting services via a web platform should enable the dynamic configuration of a monitoring and control system. Continuous knowledge and simulation based system identification during construction should increase the knowledge about the actual situation. An essential aspect of this work is the integration of description logics with relational databases for efficient storage and retrieval of sensor data and predicted data. The possibility to deduce explicit relationships from transitive relationships in a description logic by inference is a pre-condition for automation of logical decisions based on implicit knowledge. Therefore it is of considerable advantage to represent structural objects, sensor objects, processes, relationships and data by description logics and to realize their logical processing by inference. However, the recording, storage and management of high amounts of sensor data lead to some problems in practical application. The entire storage of sensor data with all necessary attributes as individuals in a description logic language like OWL-DL is very memory-intensive, because of its XML overhead. Integrating description logics with relational databases will enable the use of the advantages from both technologies: (1) the possibility to make implicit knowledge explicit by inference and (2) the high performance of relational data bases for storing and querying high amounts of data.



System architecture of the monitoring and control system

Approach

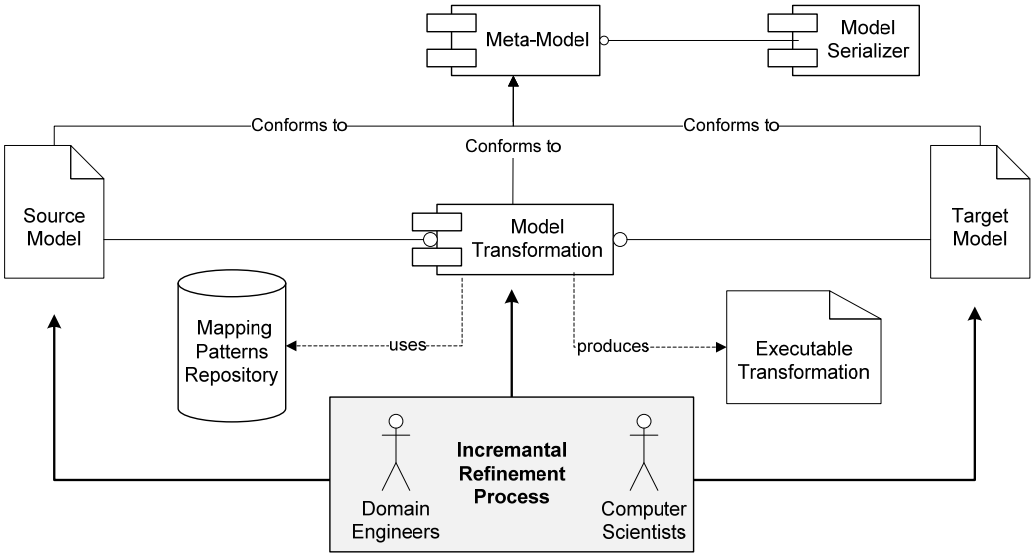
The information about sensor systems and measurement procedures will be represented as an object oriented, parametric model in a knowledge base founded on an OWL-DL description logic together with information about the engineering structure and soil as well as the construction equipment and construction measures, considering also the different phases of the construction process. Sensor data and predicted data however will be stored in a relational data base. The integration of description logic and data base will be realized using conjoint elements. Each data tuple in the data base will get a pendant individual in the description logic. The URI of the DL-individual will be introduced as an additional attribute of the data tuples in the data base. The storage of the data in the data base and the instantiation of DL-individuals should be realized simultaneously by a web service, in order to ensure the primary mutual consistency of description logic and data base. Methods for continuous consistency checks will be developed. Retrieval of data will be carried out in three steps: (1) the description logic model will be completed by explication of the transitive relationships through inference, (2) the query language SPARQL will be used to identify individuals that meet given conditions and (3) a simple SQL-query on the data base using the objects already identified with SPARQL as restriction attributes will retrieve the data associated to the identified individuals.

A Framework to Support the Development Process of Model Transformations

Sebastian Fuchs, Peter Katranuschkov

Objectives

Model transformations are one of the key aspects of achieving interoperability between different software applications. However defining such operations is a very complex task. The domain concepts of both source and target model have to be understood and their transition strategy has to be developed in terms of a programming language. In most cases this knowledge is distributed over different people and institutions and not shared between domain experts and computer scientists. The objective of this research is to improve the development process of model transformations in the construction industry where large and complex models like the IFC Building Information Model (BIM) are used. Therefore a system has to be developed which (1) enables domain engineers to declare the semantics of a model transformation without specifying implementation details and (2) allows a semi-automated process to apply standard transformation patterns to the given models. It should support incremental model refinement, beginning with a glossary, as well as automated building of the target structure when none is given. In this way domain engineers can already leverage the tool in the design phase of an interoperability process without choosing or knowing about a particular data model implementation. In the later stages of the development process, computer scientists can take over responsibility to complete all transformations. The results of the process will be consistent source and target models as well as an executable transformation between them. The target application will provide transformations between BIM, building site, specifications and process related data described in different models.



Model transformations as result of an incremental refinement process driven by domain and computer experts

Approach

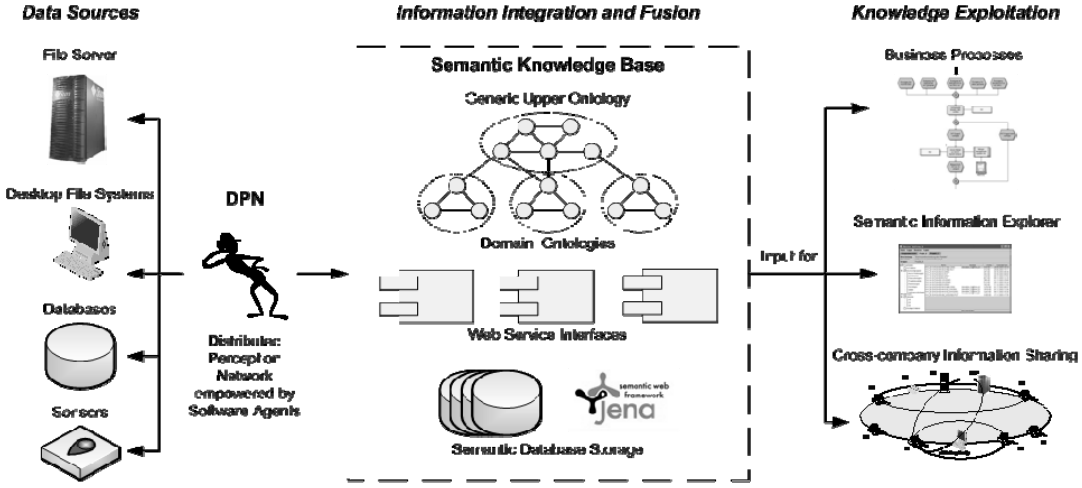
To enable the outlined model transformations a single meta-model which keeps the common structure concept for all possible source and target models is being developed. Modelling patterns will be investigated and concepts of standard meta-meta-models (e.g. EMOF) and data modelling languages (e.g. ERM, EXPRESS) will be adapted. The meta-model will represent early modelling stages (glossary) as well as a concrete class structure to which the users finally evolve their models. The model transformations will be based on that meta-model and will work semantically on the contained class structure. They are derived from basic mapping patterns developed in earlier research of the institute and are applied to the models automatically or by user interaction, depending on their complexity. Advanced mapping logic and filter criteria will be expressed in a textual programming language which may be a specialised mapping language (e.g. QVT, XSLT) or a general purpose language (e.g. Java or C#). Furthermore, a simple form of the language or a front-end for it (such as a formula editor) will be made available to end users. For the model definitions XSD is seen as most suitable at this point, but in general any object-oriented representation should be feasible when an appropriate parser is provided. The resulting transformation will be a consistent code fragment of an executable transformation language or an executable program or service. The research work and the prototype realisation of the framework are carried out within the German lead project MEFISTO.

Gathering and Fusion of Distributed Heterogeneous Information Using Semantic Web Ontologies and Agent Technology

Alexander Gehre[1]

Objectives

A prerequisite for efficient process-centred work is an adequate accessibility of relevant and up-to-date information. Integration of all information will only be successful if it can be treated in a coherent way that allows referencing and accessing it in a single efficient methodology. However, most information in current IT environments is dispersed spatially, accessible by heterogeneous interfaces and coded with task-specific formats. In order to provide for overall information awareness an integrated approach for proficient information gathering and sound information fusion is needed. For the achievement of a maximum of general applicability the approach has to respect a broad set of different information types from simple but dispersed and partially offline sensor data to standard data in files and databases to complex information in multifaceted data models and knowledge bases. In addition, it has to respect that completely centralised data management is not achievable in modern infrastructures with a huge amount of heterogeneous information. To some extent information has to remain on dedicated distributed systems, while a central meta-data management system just maintains significant expressive information about available and even currently unavailable resources. A framework that meets these objectives can provide Business Process Management with a powerful and flexible uniform technique for information integration.



Information Gathering and Fusion Using Semantic Web Ontologies and Software Agents

Approach

A hierarchical model of general and domain specific semantic web ontologies is applied constituting the semantic knowledge base of the environment. An upper model describes general concepts and specifies modelling principles and constraints. Domain specific models are plugged to the general model, extending it as necessary with specialised concepts and expert knowledge. The complete set of models is dedicated to capture heterogeneous information. If enterprise information resources cannot be integrated directly, only rich metadata are stored. At runtime the model is used to establish a semantic (virtual) enterprise knowledge base (concepts and runtime assertions). The information and metadata themselves are provided by a Software-Agent empowered *Distributed Perception Network* (DPN). It is composed of active and passive modules responsible to extract information from all data sources of the enterprise systems participating in the enterprise knowledge base. Usually, participating systems integrate a single DPN module directly; alternatively an autonomous software agent can take responsibility in observation, information extraction, analysis, condensation and integration. DPN nodes can be manifold, from simple sensors observed by agents, to local file systems of employees, to complex databases. For stored metadata, a generic yet flexible methodology for accessing the underlying information resource is an essential part of the system. As all knowledge is captured using one shared ontological system, hidden knowledge can be revealed based on defined rules and automatic reasoners. Information and knowledge contained in the system can be exploited straightforward by business process models that apply the concept definitions in their own model and use the runtime knowledge base during business process execution, e.g. for management of cross-company information and decision making.

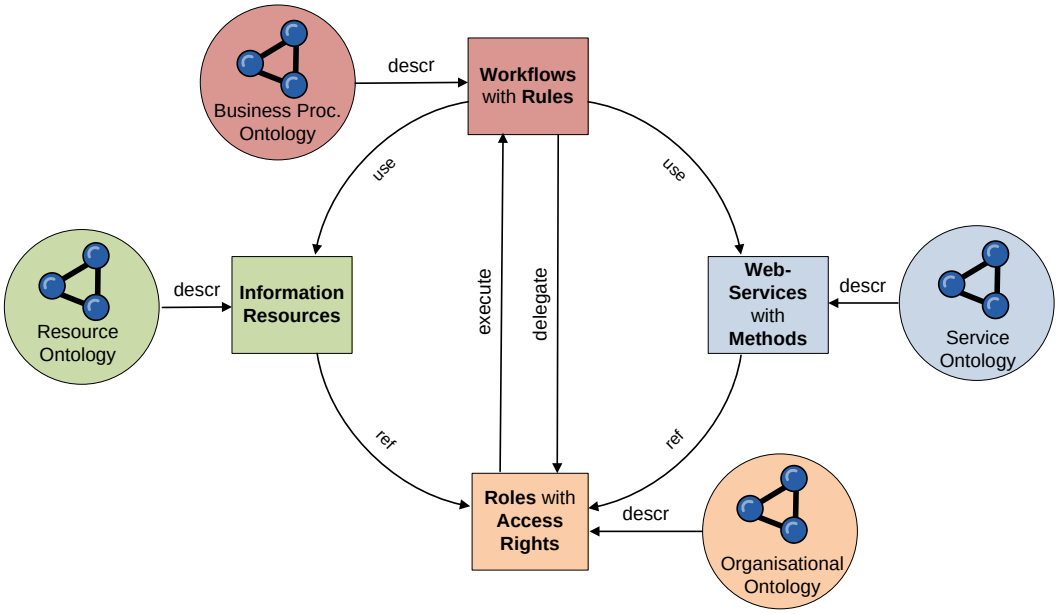
[1] Currently founding a spin-off company in construction informatics

Ontology-based Collaboration in Virtual Organizations

Frank Hilbert, Peter Katranuschkov

Objectives

In virtual organizations we have to distinguish between (1) *global knowledge* that all partners need to successfully participate in collaboration and (2) *local knowledge* describing the operational procedures of the individual partners and their corresponding company-internal sensitive information. Therefore a schema that interlinks central as well as distributed partner-specific information is being developed. Identifying, assembling and presenting this information in accordance to role-based access profiles, workflow tasks and users information perspectives should allow for sharing any critical information among the VO partners. For the execution of workflow tasks several aspects need to be considered. Some tasks can be solved solely by one partner but others will be handled in cooperation between several partners. Specifically the following requirements have to be considered: Does the partner have sufficient permissions to access the resources needed to process the task? If not, how can he delegate the task or request the collaboration of other partners? Which partners need to cooperate to process a task?



Role-based management of common workflow tasks with the help of ontologies

Approach

A hierarchical set of VO ontologies describing the organization (actors), resources and processes of virtual organizations has been developed for the area of defect management. The *Organization Ontology* reflects the principles of role-based access control and personalized context-specific user support. It is complemented with role-based business, access and representation profiles that correspond to the actors, the tasks and the client applications involved in the defect management process. The *Resource Ontology* has been detailed to store meta-data on defect records for tracking and on corresponding media data (i.e. photos, memos, videos) for documenting the defects. The defects and media data themselves are handled by a defect management and a respective media data service. The *Business Process Ontology* defines workflows to orchestrate the communication and data management processes amongst the different services. Based on an EPC (Event driven Process Chain) Reference Process Model for defect management ontology-based parametric Business Process Objects have been defined that can flexible be composed, configured and executed to coordinate the data management processes. The process configuration and execution relies on the *role-based organizational profiles* of the Organization Ontology. Hence, through the analysis of validation rules, the Business Process Ontology in collaboration with the Organization Ontology can help detect conflicts for workflow execution. With these VO ontologies a basis for the resolution of the insecurity, resulting from the distributed storage and management of sensitive VO partner data, is created. The ontology system is prototypically implemented as part of the BauVOGrid project and can be easily applied in other areas than defect management as well.

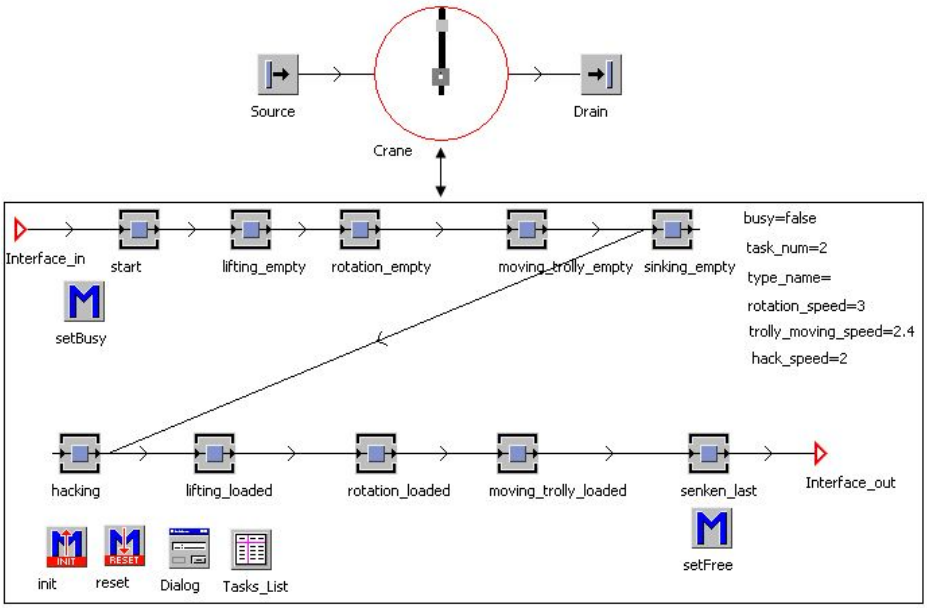
Towards Reusable Simulation Modules for Construction Processes

Ali Ismail

Objectives

Simulation techniques have been successfully applied in many different fields like plant production and logistics. Extensive efforts have been also made to simplify the application of simulation methods in construction projects in order to reduce the costs and manage the resources efficiently. However, due to the one-of-a-kind nature and the high degree of complexity in construction processes use of simulation in real projects is still very limited. Especially the lack of specialised and easy to use simulation libraries concerning the construction projects makes building a sophisticated and realistic model a very time consuming task.

This research aims firstly at offering a set of reusable and flexible modules for construction processes using market simulation tools. Such modules are expected to lead to large reduction of the required time and the complexity of creating the simulation models. Secondly, it aims at developing an XML-based model describing the construction site layout so that data from the site can be seamlessly integrated in the simulations. The aimed simulations will cover the improvement of construction site layout, the management of storage yards, and the process of selecting material transportation means during the whole construction phase. The developed tools will be an important aid to answer questions like (1) the location and size of storage areas, (2) the number, location and capacity of required cranes, (3) the materials delivery schedule.



The tower crane as a reusable simulation module

Approach

Using the basic material flow and resource elements in market simulation tools as starting point, new modules will be developed to offer off-the-shelf configurable objects for the domain of the construction industry such as cranes, stockyards, networks of transport ways, etc. The functionality of these new modules will be transparently exposed to the end users, and their behaviour and work logic will be encapsulated in a hierarchy of sub-elements, thereby allowing them to be extended or fine-tuned.

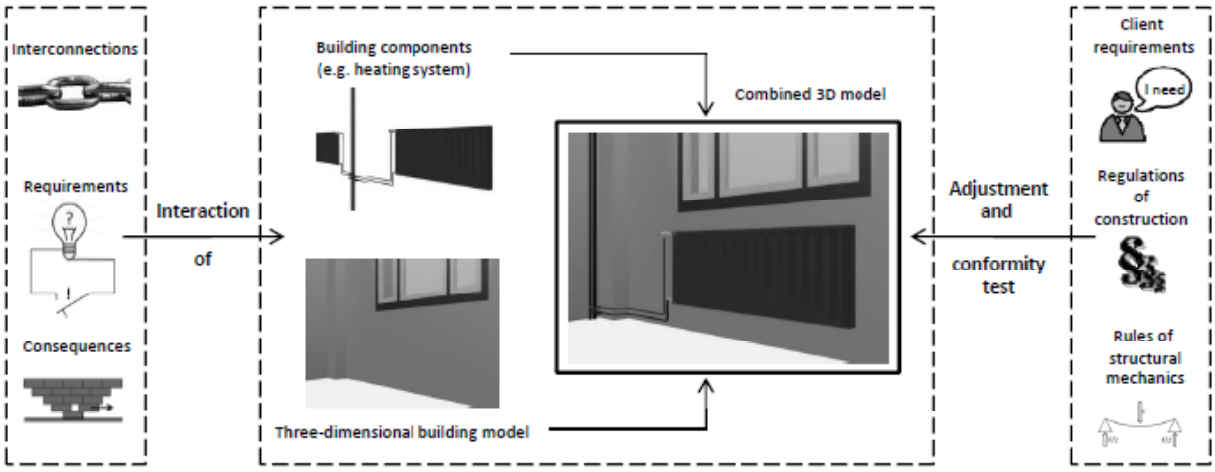
The modular structure of the market simulation tools and the standardised data exchange interfaces (ODBC, XML, ActiveX) enable making the necessary external data available during the simulation. Especially the building model data (via ifcXML), the project planning data, and the available resources data will be integrated. This allows the use of the same simulation model for different projects with different combination of resources without changing the principal structure. The layout of the construction site including the building areas, storage areas, cranes locations, etc. will be described through an XML schema to make import/export/auto-generate functionalities possible. The modules will be developed in the frame of the MEFISTO project and tested using typical cases from real projects for verification purposes.

Building Management Systems on the Basis of a Virtual 3D-Model

Ronny Sachse, Martin Just, Undine Kunze[1]

Objectives

Advanced building management systems increasingly require a current and exact assignment of all the technical facilities in a building to the building elements in order to operate effectively for the client requirements. Therefore, the research project V3CIM[2] was launched in March 2009 at the University of Applied Sciences Dresden in order to establish a comprehensive and accurate 3D Building Information Model (BIM) of the campus infrastructure. The aim is the development of an integrative system for the construction, the operation, the management and maintenance of an interactive 3D virtual model including the architectural and technical infrastructure of a university. It should allow combining of the architectural structure of a building with internal objects and facilities like the central heating system, the sanitary water and wastewater systems as well as the complex electric system. Currently, most of the information exists in 2D technical drawings, tables and sketches and documents whether in digital form or hardcopy. By using software products which offer architectural and building systems design at the same time, the resulting files will already include all element information but do not completely consider their relationships. The interaction like connections, requirements and consequences between different classes of objects will be the main focus in such an integrated BIM. An important task is to meet the client requirements, regulations of construction and the rules of structural mechanics while changing the structure or the facility.



Arrangement of building structure and facility objects in a combined 3D model, i.e. integrated BIM

Approach

In order to integrate a three-dimensional model in a modern computer aided facility management system (CAFM) the building geometry, spatial relationships as well as quantities and properties of building components for building services has to cooperate in only one model. The partial independently existing software applications are highly developed on their own field of interest but still provide particular problems by interactions. Thus, unequivocal connections between building and equipment objects should be integrated and documented in the case of one-sided changes. Besides, such relations – also potential collision problems of building equipment or technical machines with building objects, when removing them – will be integrated in a future BIM. Automated warning reports and advice reports will make future changes or adaptation of the building components easier. Breakthroughs in objects like walls or slabs will automatically be generated whiles designing a pipe system and should be checked by an instant adjustment and conformity test in order to follow client requirements, rules of structural mechanics or regulations of construction.

In cooperation with system operators and facility managers of the University of Applied Sciences Dresden the requirements for a building information model will be worked out in order to balance client needs and technologies available. Thereby, ongoing refurbishment projects will be used to test the efforts in the project in order to meet the university needs.

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

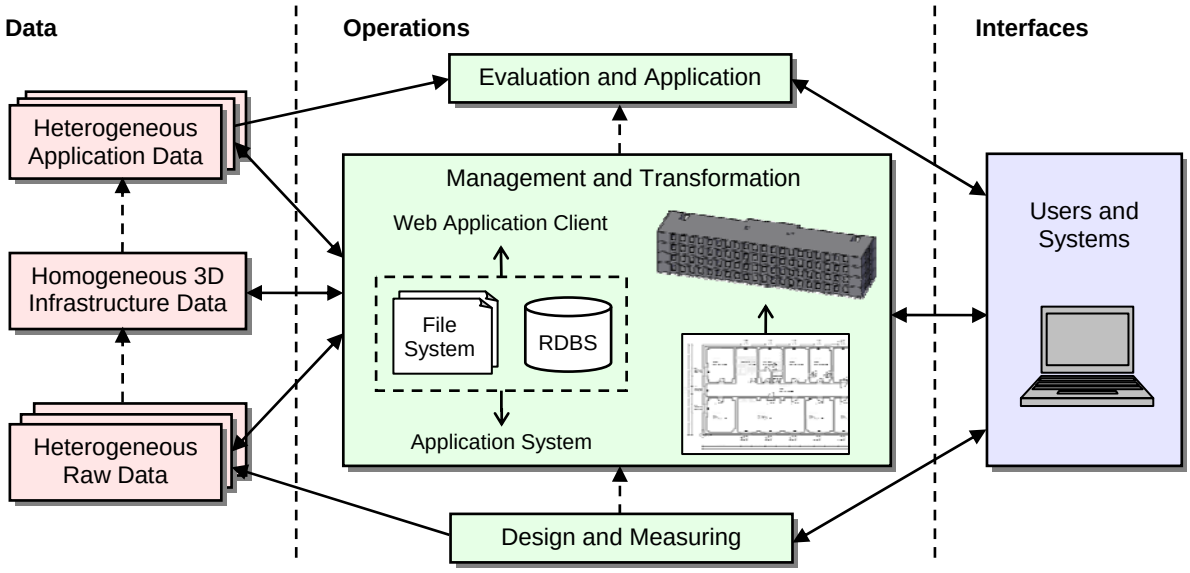
[2] V3CIM (Virtual 3D Campus Infrastructure Model) – http://www.htw-dresden.de/~v3cim – supported by the Saxon State Ministry of Sciences and Arts.

Managing Data of a Three-Dimensional Campus Infrastructure Model

Hermin Kantardshieffa, Wolfgang Oertel[1]

Objectives

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



Software architecture of the Campus Infrastructure Information System

Approach

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

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

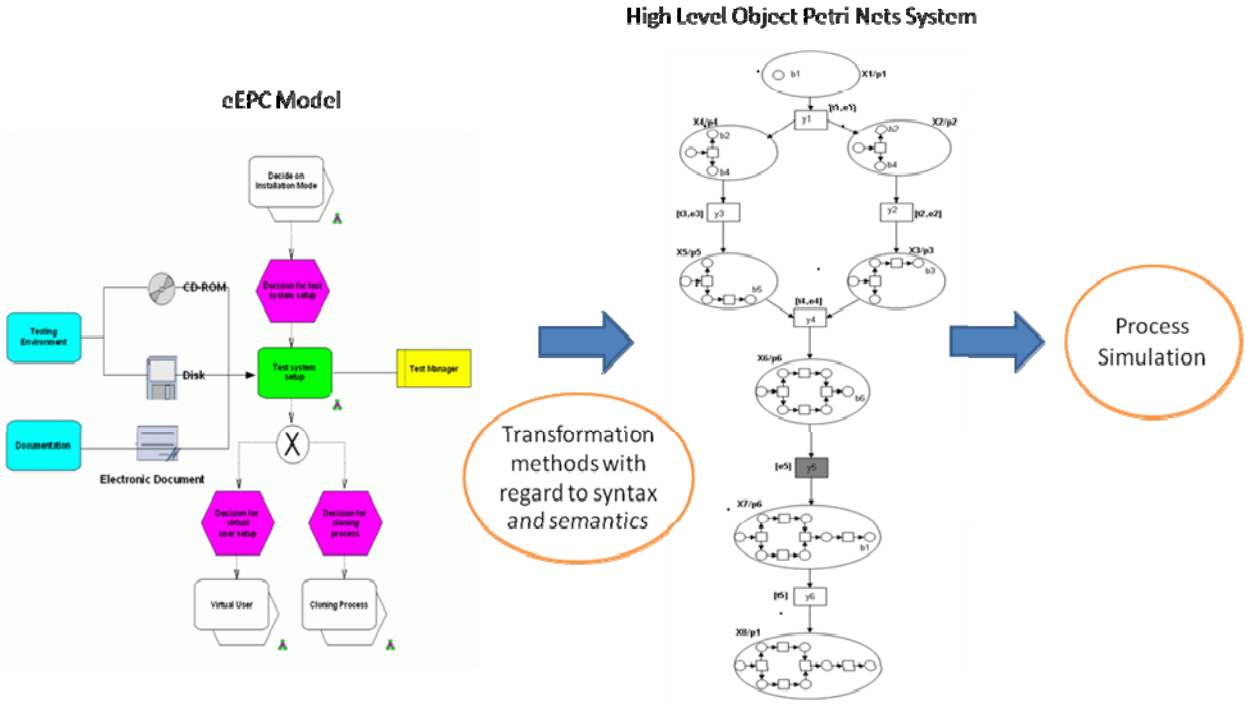
[2] V3CIM (Virtual 3D Campus Infrastructure Model) – http://www.htw-dresden.de/~v3cim – supported by the Saxon State Ministry of Sciences and Arts.

Transformation of eEPC into High Level (Object) Petri-Nets to Support Processes Simulation

Faikcan Koğ

Objectives

Business Process Modeling is one of the important concepts of the Business Process. A common and effective tool of the BPM is EPC (Event-Driven Process Chain) or and eEPC (extended EPC). These tools invented to modeling and hence are not useful to simulate process or to optimize project elements. The situation is also same for the construction projects, which has more complex process according to the business projects. Here the solution to develop these tools for better processes is the transformation of these tools into more mathematical models or computational models such as Petri Nets. Already there are some existent works to transform eECP to colored Petri Nets. But these types of high level Petri Nets have not enough or not suitable (exact) syntax and semantics for further complex works and systems. And also the aim must be transformation of eEPC to the Object Petri Nets (nets within nets), which allow the modeling of concurrency, synchronization, and resource sharing behavior of a system, and have large scope and chance integrating with the object oriented software design. Object Nets have well structured architecture and with this transformation they can supply the demands of project managers. The objectives of this research are to convert eEPC to Object Petri Nets, to simulate processes with an Object Oriented Programming tools and to optimize the important three legs of the construction projects; quality, time and cost.



Transformation of the eEPC to the Object Systems (The General Aspect)

Approach

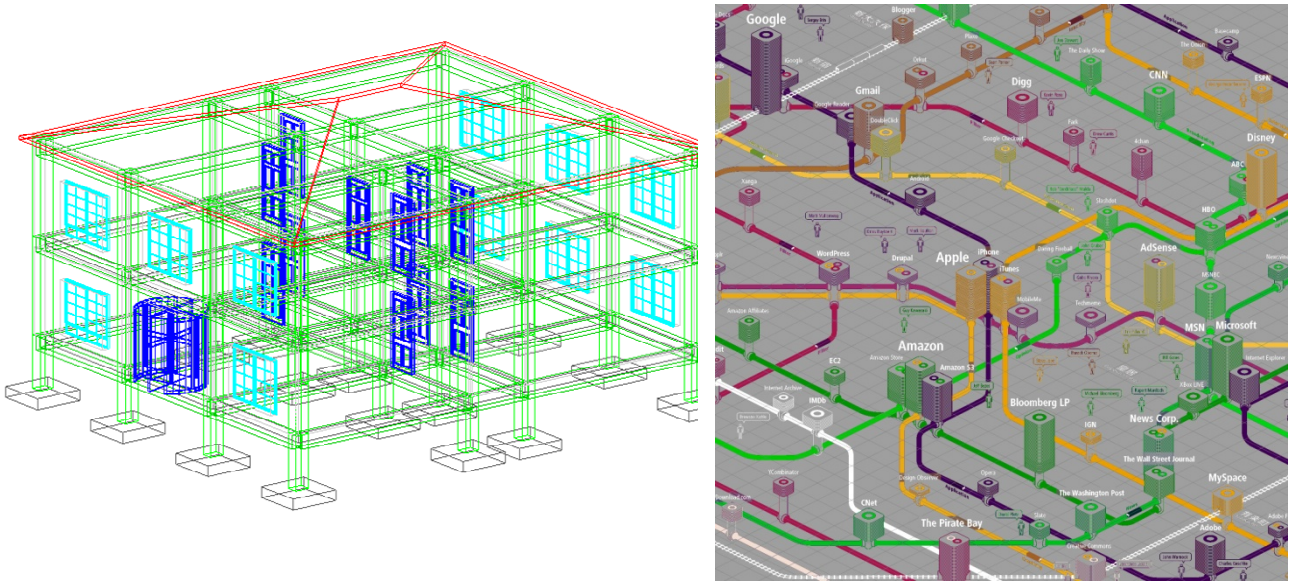
The transformation process must be started with rearranging of the syntax and semantics of the eEPC. It must be suited and formalized to the mathematical ground. Then with the new syntax and semantics (by the new methodology) there would be well-structured conversion to the Object Nets. All elements of the eEPC must be re-defined and suited to the mathematical structure of the Object Nets Systems. The next step will be the visualization of the transformed models and construction of the Object Systems with its tokens transitions. This research plan is set up according to the context of the German lead project MEFISTO.

Visualization of building and construction management information

Romina Kühn

Objectives

The focus is on a platform which displays complex information being associated with the field of civil engineering. The information mainly include costs, appointments, activities, buildings, construction sites and construction specifications. For all of these points there has to be specific methods to visualize them. Thus the objective of this work is to develop a viewer system. The way of visualizing different aspects results in different views because not all information has to be visualized in the same context. For instance the building can be used for displaying the construction progress or costs. Hence a building centered visualization view is needed. The most common data format for this type of view is the IFC format. Within this format all required visualization types must be integrated. Another important view shows construction site centered visualizations. Here the focus is on the construction equipment. Thereby the visualizations can consist of animations deduced from simulations of processes and activities as well as risks, costs etc. A third visualization view consists of topological networks which will be useful for logistics and complex dependencies between objects and models like risks or timing. To visualize all of these complex relations there has to be a common base not only concerning the data format but also in terms of the visualization itself.



(Source: http://informationarchitects.jp/web-trend-map-4-final-beta/ Online available: November 6th, 2009)

Building (left) and topological network (right) centred view using route map metaphor for multi-model information and interdependencies

Approach

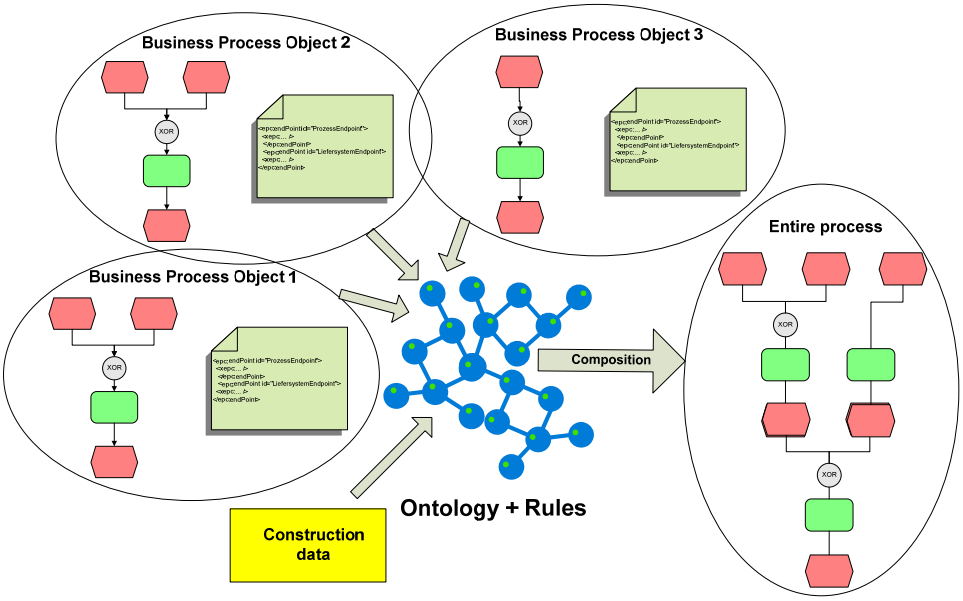
To solve the problem of seamless usage of the different visualizations a visualization ontology has to be developed managing requirements (context, user role, decision type and granularity), visualization types (dashboard, maps, diagrams, tables, 4D, 5D, etc.) and content organized in models (building, organization, construction site, specification, process, risk). The most important aspects are which type of visualization is qualified for which kind of content and how the content can be visualized in general. For instance there is no standardized way to display risks or dependencies. For this visualization of topological networks route maps seem to be a possible approach. Furthermore the processes must be categorized with the focus on user, context and view. Every user has special requirements on the information he wants to see. Different roles must be defined. Therefore the different user profiles must be evaluated and connected with various situations in which the user has special views on the building or construction site. For very important views the technique of dashboards seems to be a good approach for the visualization. Because all content models show different data formats interoperability has to be developed too. The research is carried out in the framework of the MEFISTO project where for instance basic construction ontology as well as interoperability methods are contributed by other researchers.

Ontology-based Business Process Management Using Adaptable Process Knowledge

Ksenia Rybenko, Peter Katranuschkov

Objectives

Business process modelling has proved to be a powerful instrument to describe and manage the increasingly complex processes within and across enterprises. Today, it plays an increasingly important role in the AEC industry as well. However, it requires a significant amount of manual work to create, adapt and maintain business processes. Even currently construction projects are still managed on the level of scheduling. This workload could be reduced if business process models are semi-automatically generated and adapted. To achieve that, appropriate process formalisation is needed.
The hypothesis of this research is that an ontology knowledge base representing business process patterns with related construction data together with the strategic and tactical knowledge about process configuration and composition can provide a collaboration model with clear and unambiguous semantics, thereby facilitating integration and reuse of existing business processes and data models. Modelling of the construction processes can be done at the outset using ARIS methodology and extended event-driven process chains (eEPC) in particular. However, eEPCs lack fully formalised mechanisms that can enable flow control together with proper resource assignment to processes and explicitly defined actors/roles with respective process-related responsibilities and access rights. Therefore, a formal representation of eEPC in an ontology is sought that can also support retrieval, configuration, composition and consistency checking of the business process.



Principal business process management by means of ontologies and rules

Approach

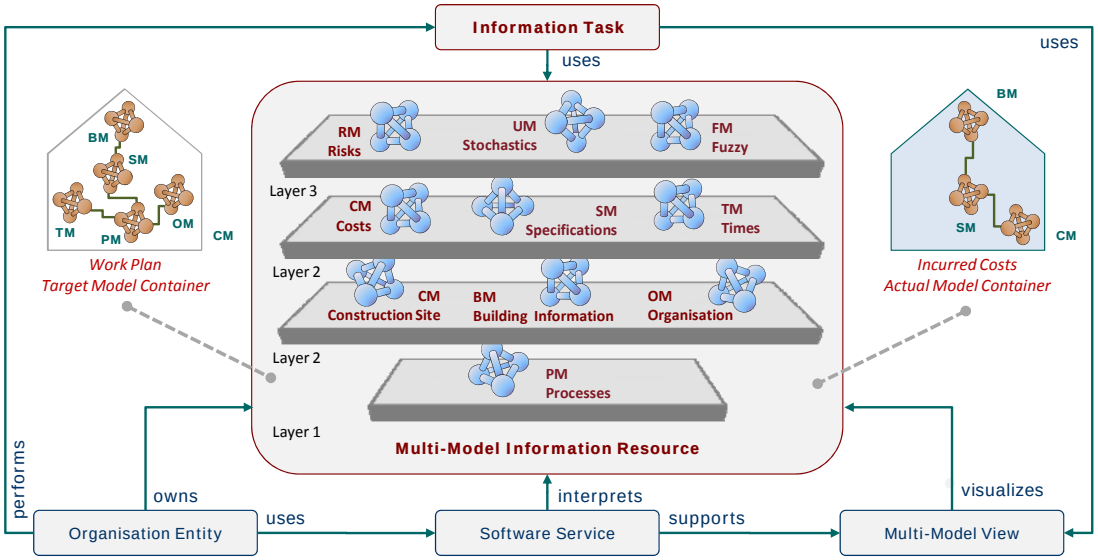
EPC process patterns together with the related data can be formalized in F-Logic. F-Logic is an ontology language which combines the declarative semantics and expressiveness of deductive database languages with the rich data modelling capabilities supported by the object-oriented data model. An automatic formalisation succeeds through the transformation of eEPCs in XML-format into F-logic format. For the mentioned formalisation requirements sets of specific rules are developed, namely (1) a *configuration rule set* providing non-ground rules that define how the relationships between process components work, (2) a *component description rule set* providing ground facts that define what process components are available and what relationships they have with other components and (3) a *user requirements description* providing ground facts that tells what properties the user wants the process to have. A framework built up around these three rule sets will allow for dynamic composition of intelligent process modules, thereby supporting process management with high-level reasoning on every stage of a construction project. Developing such a framework started in the German collaborative project BauVOGrid and is currently continued and extended in the frames of the German lead project MEFISTO.

Ontology-based Information Framework for Sharing Construction Planning and Management Models

Sven-Eric Schapke, Peter Katranuschkov

Objectives

Decision making in construction planning and management requires access to latest and consolidated information of building and construction plans as well as corresponding controlling applications. Semantic Service Environments with dedicated information logistics and analysis services provide for the build-up of Management Information Systems that can support information sharing processes among different disciplines, functions and management levels within the owner's and the contractor's organisations. Information interoperability can partially be realised with existing standards, such as the IFCs that have been developed for integrating the discipline-specific models of architects and engineers in building design. However, to be effectively applied, relations with the often proprietary models of construction tasks and resources as well as the organisational entities, roles and processes need to be established. Moreover, mechanisms are required to support the organisation, combination, analysis and visualisation of inter-related models with varying status, domain focus and level of detail for the purpose of different decision making levels.



A Construction Core Ontology for sharing Multi-Model Information Resources

Approach

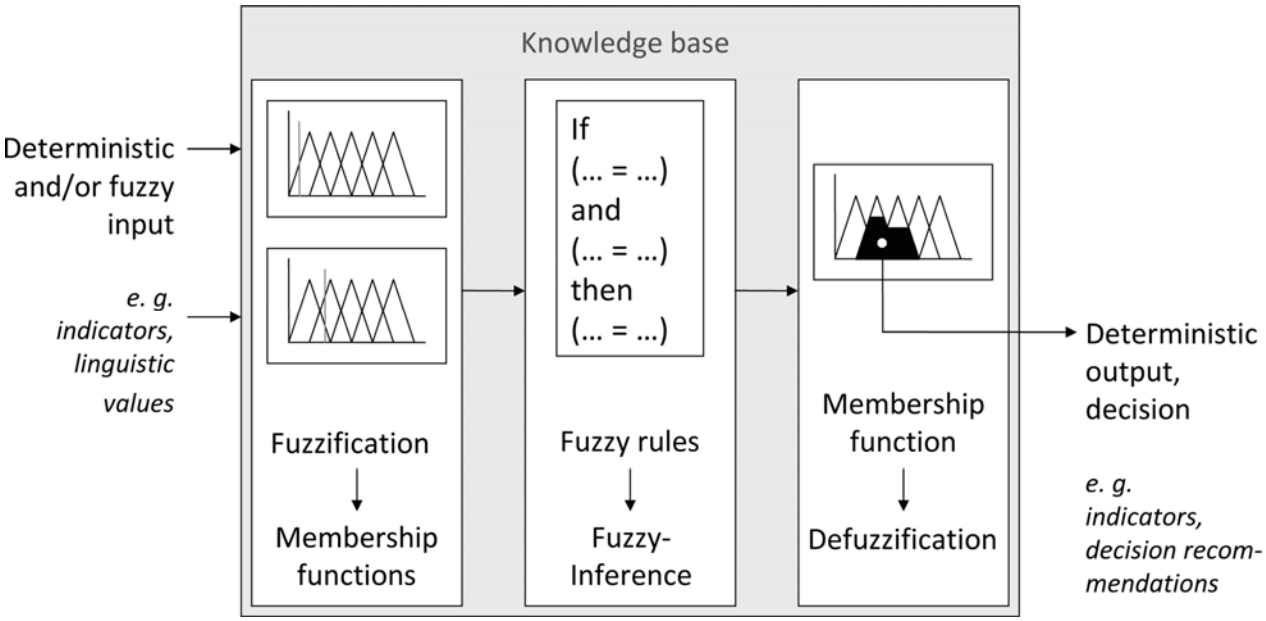
A layered ontology-based information framework is developed to coordinate the logistics for creating, consolidating and re-using model-based construction planning and management information. The first three layers define a *Construction Core Ontology* that inter-relates concepts of selected standard as well as non-standard data models. The first layer represents processes (PM) of information and building production. The second layer comprises concrete construction elements and resources of building information models (BM), construction equipment and material models (CM) as well as organisation models (OM). On the third layer qualitative descriptions of the first and second layer concepts are represented specification (SM), time (TM) and cost models (CM). The third layer comprises risk models (RM) as well as formal stochastic (UM) and fuzzy models (FM) to weigh and evaluate the qualitative models. The Construction Core Ontology allows for coupling model-based information in *Multi-Model-Containers*, i.e. logical envelops for handling distributed, yet inter-related application models as single information resources. Moreover, it provides for the semantic annotation of the containers in accordance to their model types, formalizations and relationships. The fifth layer finally defines a *Project Collaboration Ontology* that encapsulates the Core Construction *Ontology* on the first four layers as information resources and describes their user context. It identifies role, form and detailing of core construction objects within typical single-application models, composite multi-models and corresponding multi-model views used throughout different disciplines, management levels and project phases. Moreover, the Project Collaboration Ontology also describes the Organisation Entities as well as their information tasks and the software services that can read, create and interpret the information resources and corresponding multi-model views.

Integration of uncertain knowledge into processes of operational construction management

Ulrike Schirwitz, Uwe Reuter

Objectives

Many information, parameters and boundary conditions in construction process modelling are only available as uncertain values. Especially the aggregation of information used for vertical model transitions requires the consideration of uncertain information. Another application is risk management where as well most values cannot be stated precisely. A realistic simulation of construction process management depends on the quality and complexity of computational models and methods as well as the reliability of available input data. The intended research is aimed at capturing these uncertainties. Methods of fuzzy logic and fuzzy analysis provide a promising approach for mapping and computation of those uncertain information. Furthermore, fuzzy analysis is an appropriate solution for risk management under consideration of uncertain knowledge.



Fuzzy controller for decision making and risk management

Approach

Fuzzy logic is a multi-valued logic derived from fuzzy set theory, where the degree of truth of statements can not only take the values 0 or 1, but also values in between. This enables consideration of empirical expert knowledge and rules, which are usually given in linguistic form. Linguistic information and rules are a priori uncertain, as they express the subjective opinion of the expert. However, fuzzy logic opens a possibility to formalise this information in a quantitative manner for computation and simulation and hence avoiding artificial averaging.

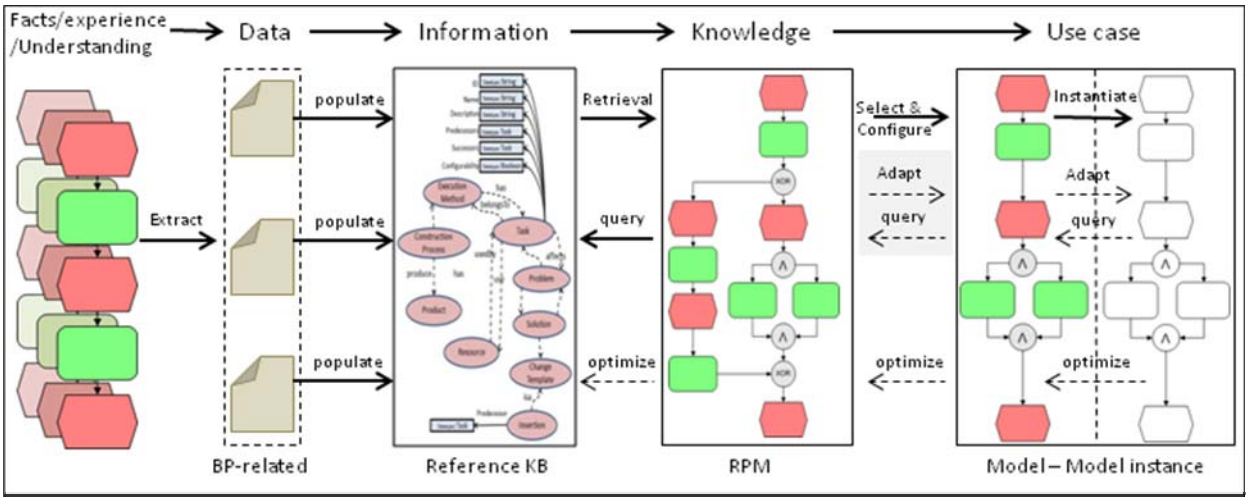
For processing of uncertain data, parameter and boundary conditions algorithm of conventional fuzzy logic approaches has to be enhanced. In order to obtain a deterministic control action, methods of fuzzy inference has to be developed for mapping of fuzzy input variables. The figure above shows a fuzzy controller with fuzzy input as extension of conventional methods. Aggregation of information may be handled by using such fuzzy logic, which means that fuzzy input - i.e. several indicators - will be summarised to one or several indicators of a higher level. Alternatively, the application of methods of fuzzy analysis for the purpose of decision making is to be analysed. In context of process modelling resource information within business process objects are also modelled as fuzzy parameters and processed with the aid of fuzzy analysis.

Configurable Reference Models for the Building Processes

Wael Sharmak

Objectives

A construction process is an unstructured and dynamic course of action. Such processes are totally dependent on the specific needs and resources of the project, which are generally different from a project to another. Moreover, building projects include usually a lot of uncertainty. Therefore, it is mostly impossible to apply the exact process, as explicit work route, in different projects. The experience plays a crucial role to manage the same process in different project contexts. The collected process-knowledge is therefore valuable for the effective process management. Unfortunately, this knowledge is mostly available implicitly in the mind of each person involved in the corresponding building process, i.e. it reflects his/her experience in this process field. Such implicit knowledge will be lost if its owner will not be present in the company for a reason or another. Therefore, this knowledge should be reposited in an explicit way to enable all the company members to share and use their common experiences in a proper way. As business processes are both knowledge demanding and knowledge generating, they can be considered the initial point for/ and the result of the *Business process-oriented Knowledge Management*. The main objective of this work is to store this knowledge in *Reference Process Models (RPMs)* that should consider the special characteristics of the building processes, e.g. unstructured and dynamic process context, by offering configuration and adaptation functionalities. In the same time the approach should enable the reuse and the continuous optimization of these *RPMs*. The problem semantic/contextual queries and the retrieval from the *RPMs* pool should also be supported by the intended approach.



Knowledge life-cycle for Building RPMs

Approach

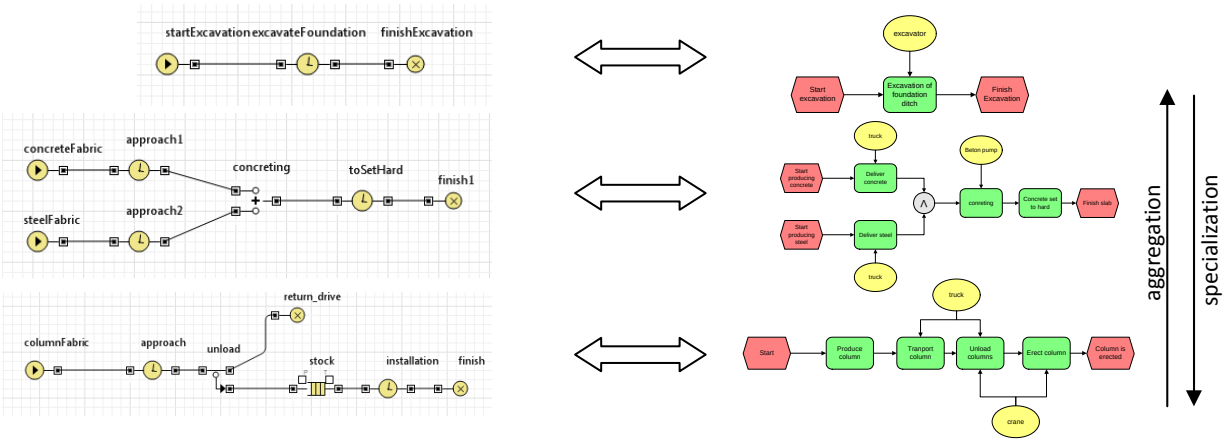
Event-driven process chains (EPC) is one of the common methods to model business processes. EPC supports also reference modeling as it has configurable components. In this work EPC models are adopted as the initial point and as the result of the knowledge management process. The needed classes and constraints to model the building processes as PRMs considering the EPC specifications can be realized using the concepts of Ontological Engineering. An ontology populated with process data will build the PRMs knowledge base. Accordingly, a clearly defined semantics for the process models can be achieved by instantiating the elements of a RPM from the concepts of an ontological knowledge base. Moreover, storing the RPMS' building blocks in the ontological knowledge base will enable to make advanced queries when retrieving information which may even infer facts that were not explicitly created by the modeler of the PRM. According to the use case conditions, the configuration of a RPM in the planning phase as well as the adaptation of the model/model instance in the execution phase should succeed using the Change Templates developed previously in our institute. Each change template describes one way of structure change in the process model. Therefore, by assigning a change template in the RPM to each exceptional/ configurable element the inclusion/exclusion of it in the model/model instance can be done automatically. The whole approach can help to speed up the design of the business process models and to study the effect of specific situations as What-If scenarios during the planning without endangering the success of the process objectives.

A BIM integrated Simulation Model for Construction Processes

Ulf Wagner

Objectives

To enable simulation for constructions sites it is necessary to reduce model setup time drastically. One approach is to modularise the simulation and to create a library of modules, which are quickly combinable. This library should contain typically elements for the simulation of a construction site like erection of columns or concreting of a slab. These single elements, so called modules, should be designed in a way, that they are combinable to subsumed macro modules. These subsumed modules should likewise be again combinable. At a defined higher level the modules may be not longer simulations modules, they may change to business process objects (BPO), which may be handled and processed outside the production simulation in other tools. The bottom-up subsuming should also be completed with the top-down specialisation. BPOs should be fissionable in smaller modules. Therefore are rules, tips and tolls necessary, which are provide to end users.



Production Simulation components and their responding eEPCs and resources

Approach

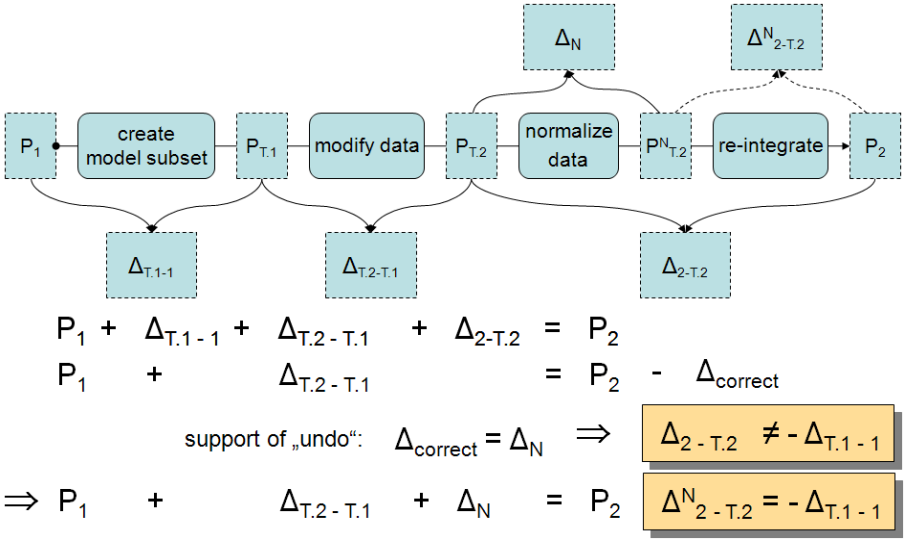
The first step is to identify which kind of simulation methods is appropriate. Two type of simulation are conceivable, agent-based simulation and event-driven simulation. Both methods have advantages and disadvantages. Event-driven simulation is better map able to event-driven process chains then agent-based simulation. But with agent-based simulation people and equipments at the construction site are better map able. Indeed it can happen, that both simulation types are used, depending on constrains. As example on the lowest level of granularity, agent-based simulation may be the better solution, because at this level acting persons are prominent, where as all higher levels event-driven simulation will be used. Typical simulation worthy constructions processes are to be identified, analysed and classified. Afterwards simulation modules should be created for these processes and provided in catalogues. During modularisation all the time it is to ensure, that the modules are combinable with each other. Therefore an interface between the single modules is to be defined. At this interface resources and process flow are to be connected. The modules can be either *plain old java objects* (POJOs) in AnyLogic, a Java based simulation tool. Inside these Java objects, the objects from the simulation enterprise library will be combined to process flows. For example the module for concreting a slab consists of the simulation library modules *source*, *sink*, *combine* and *delay*. Although *delay* is a very simple module which only consumes time, many process items can be simulated as *delay* because time consumption is beside resource consumption one of the most important issues and of course the final production output quantity. Objects like *combine*, *split* or *match* are not time consuming. They control the flow and only if a lack of input entities exists they will consume time in waiting for input entities. The subsuming of two or more modules to one module in a higher level effort intelligence methods of subsuming, which compressing the characteristic values in a way, that the typical behaviour of the subsumed simulation modules will not be lost. Furthermore it is necessary to provide a pool of resources, which is assessable over all modules. Modules are only allowed to use resources from this pool and hence lack of resources can be determined. During the transition to a higher level these resources have also to be subsumed and possible overlappings in the resource use are to be tagged.

Normalization of Modified Partial Design States in Change-Based IFC-Product Data Management

Ronny Windisch

Objectives

The complexity of the IFC model schema has increased significantly over the last decade. The effort paid in understanding the complete IFC model in order to implement it correctly becomes an important issue to the community. Several studies indicate that the translation of the IFC data through a design tool has to be considered as incorrect. This means the design tools change the model data only through import/export procedures without any manipulation by the user. Therefore the use of model views that should provide only the model data that can be fully interpreted by the addressed design tool in order to avoid uncontrolled data loss is not sufficient to prevent the model data from unintentional model changes. These artificial model changes leading to inconsistent model data that is inappropriate to determine the essential design changes that provide the basis for reliable product data management. However, the level of the unintended model changes done by a design tool strongly depends a) on its application parameters (application domain and function, internal model representation, quality of IFC schema implementation) as well as b) on the local representation parameters (e.g. use of different units of measurement, different positioning references) characterizing the local representation of the partial design state (i.e. the model subset). These influences can lead to serious model changes on object level (a), like object removing, fragmenting etc., with according effects to the objects references and on the attribute level (b) without structural changes of the model data. The normalization process has to retract the unintended changes in order to ensure uniform representations of the model data over the origin ($P_{T.1}$) and the user modified partial design state ($P_{T.2}$) referring to the global design state (P_1).



Principle formalization of model data normalization in change-based product data management for the definition of succeeding design states

Approach

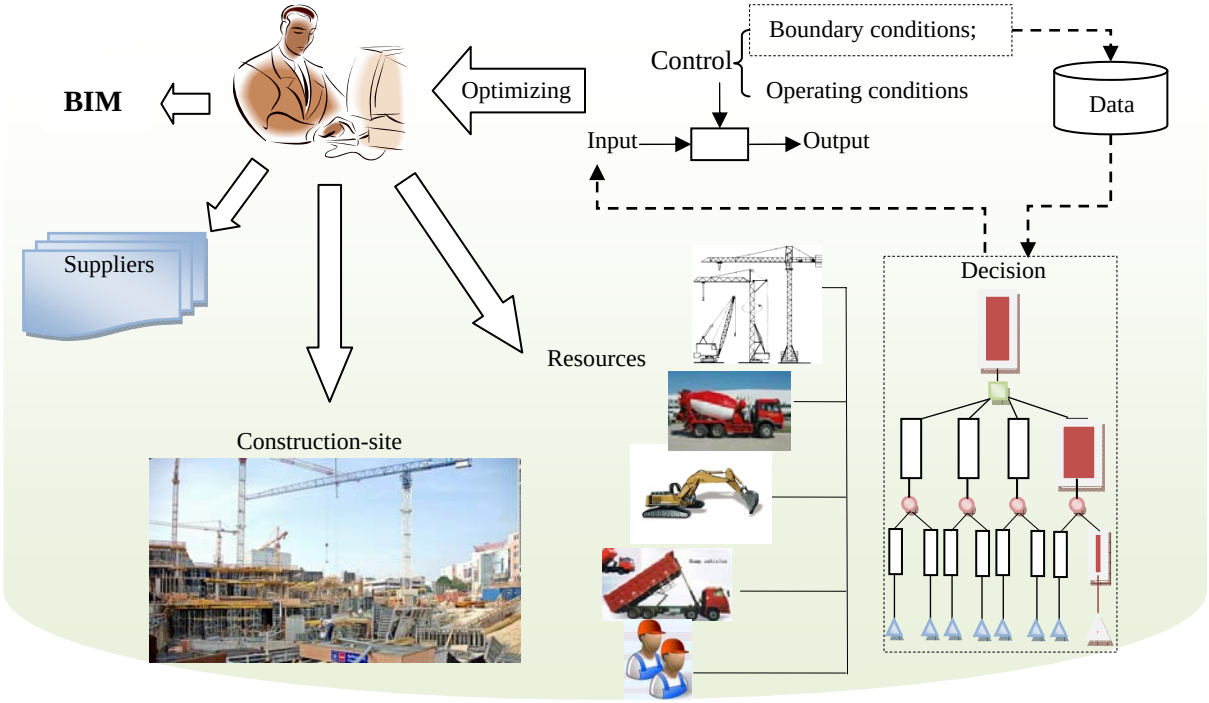
The normalization approach extends the definition of the succeeding design state (P_2) with regard to the unintentional design changes that cannot be fully predicted in any case. Therefore the amount of model data that has to be retracted by the normalization process is a subset of the total set of changes ($\Delta_{T.2 - T.1}$) between both partial design states (essential design changes may have to be normalized too). The normalization process becomes a part of change detection since it needs full support of the model matching and comparison algorithm. The challenging task of the normalization process is to identify the artificial changes and to separate it from the essential design changes created within users work task. However, the normalization process replaces the differing representations in the modified model subset by the equivalent representations (Δ_N) according to the original model subset. The substitution is based on predefined transformation rules derived from general application and representation parameters describing the expected model changes.

Effects of environmental boundary conditions on material flow and supply logistics at the construction site

Yaseen Srewil

Objectives

Uncertainty in construction industry has a considerable rule in delaying the execution of construction projects. Furthermore, construction operations are subject to a wide variety of fluctuations and interruptions especially environmental and site conditions such as, climate (storms, mega wind, heavy snow, etc), equipment breakdown, trench collapse, and labor strikes. These make the project activity varying in time and resources. Also, these effects take place mostly sudden without sufficient warning signal. Therefore, project management needs dynamic planning tools to account such uncertainty. Furthermore, it needs a realistic simulation for complex production at the construction site. Whereas the simulation is a significant tool to enhance project scheduling, re-estimate, provide or eliminate and represent the progress of the project during the execution phases. Likewise, many of these construction site demands are not included in the current simulation tools in civil engineering. The objective of this research is to study the boundary environment effects on the construction site and suggest solutions to bridge the gap between the current simulation tools and the demands of working on the actual construction site. Moreover, these simulation tools should be extended to consider these dynamic effects on material flow and supply logistic in and to construction site.



Schematic of integration of boundary conditions in construction site

Approach

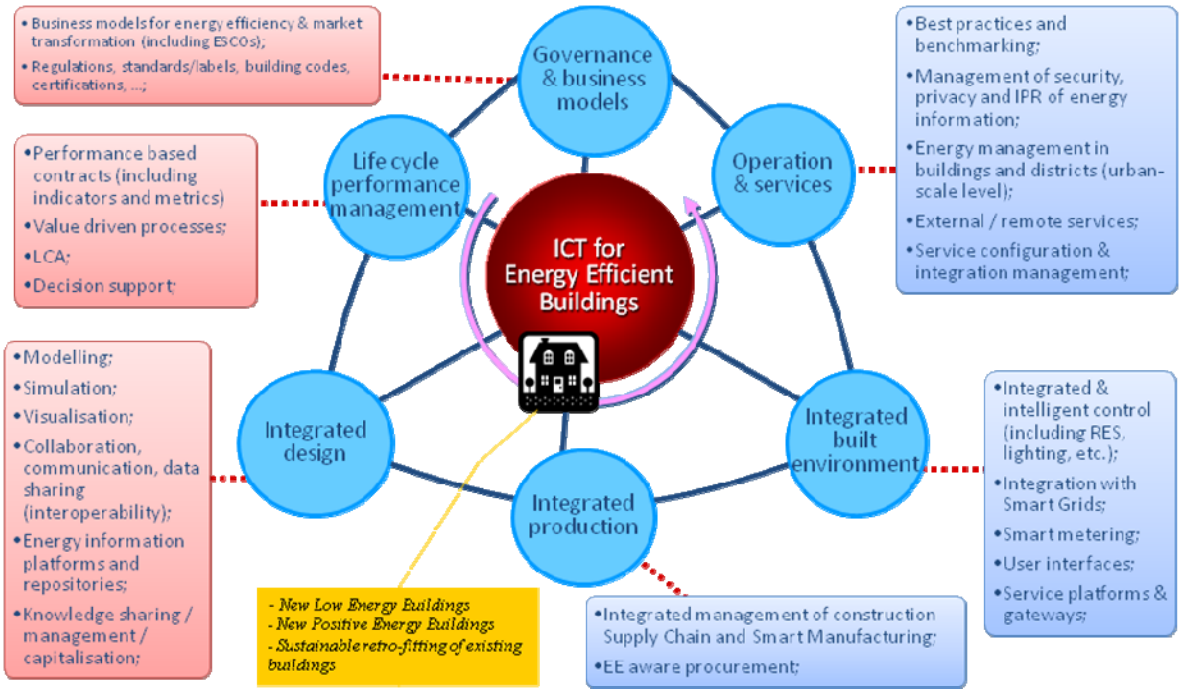
The integration of the boundary environment conditions, changing of construction site parameters and restrictions at the site can be realized by using decision trees (DTs) solution. Decision trees are one of the most attractive and easy to use tools in decision-making. They analyze decision alternatives in a systematic and chronological way and provide an easy to read graphical presentation of decisions under consideration. Decision trees will be used as implicit tool in the simulation interface for material flow and logistic process. One of the problems that can be solved using DTs is the effect of weather conditions on construction site. The histograms of weather attributes from metrological database for the construction area will be used as input. The decision tree shows the attributes with the most information gain at the top of the tree towards the bottom. The next step will be visualizing the result from the decision tree. In this step the possibilities of extending proprietary simulation tools with decision tree models will be discussed. The expected results are: a clear idea about the material transport system efficiency, decision support to use alternative resource, project specification quantities or the time of the activity and optimization criteria for adapting the project plan.

Contributions to the European Strategic Research Roadmap to ICT enabled energy- Efficiency in Building and Construction

Tatiana Suarez, Thomas Eisenreich

Objectives

Energy efficiency is a key challenge of the future world, the challenging opportunity of today is the implementation of the measures to improve management of energy in Buildings over the whole lifecycle, and the ICT support at all stages of it. The vision for ICT supported energy efficiency in construction is developed in relation of RTD priority areas. Six basic categories are identified (see figure), where at high level of impacts of ICT the evolvement of RTD is envisaged at three stages: short, medium and long term. The development of the proposed selection and evaluation criteria is based on a bottom-up qualitative analysis of recently completed and ongoing research projects leading to an initial specification of common classification criteria. The objective is to provide a comprehensive set of Selection and Categorization Criteria for key research projects focusing on ICT-based energy-efficient management of build artefacts and systems, including novel methods for modelling, financing, operation, and maintenance processes.



Identified ICT based categories for Energy efficient building developed by the REEB consortium

Approach

The improvement in energy-efficiency through innovative ICT can be engaged by ICT methods and tools (1) supporting optimal design of products and services with respect to energy consumption and the related environmental impact, with coverage of the entire life-cycle of products and services from requirements analysis to their final elimination, and (2) by the integrated ICT-based systems to enable an eco-efficient production, conservation and distribution of energy, guaranteeing safe and reliable provision of energy and possibly integrating various energy sources and transformation processes (e.g. cogeneration).

The new ICT-based control and monitoring systems (industrial processes, office buildings and living environment to optimize energy consumption and reduce environmental impact) are related to the design, simulation, evaluation and strategy adaptation of energy use profiles, especially in terms of in-house/in-building consumption management, with a focus on energy-neutral new or renovated home and working environments, supported by innovative business models and platforms for energy efficiency service provision. The findings are to be disseminated in the usual channels and in addition via e-Lecture notes developed by the Institute of Construction Informatics at the TU Dresden.

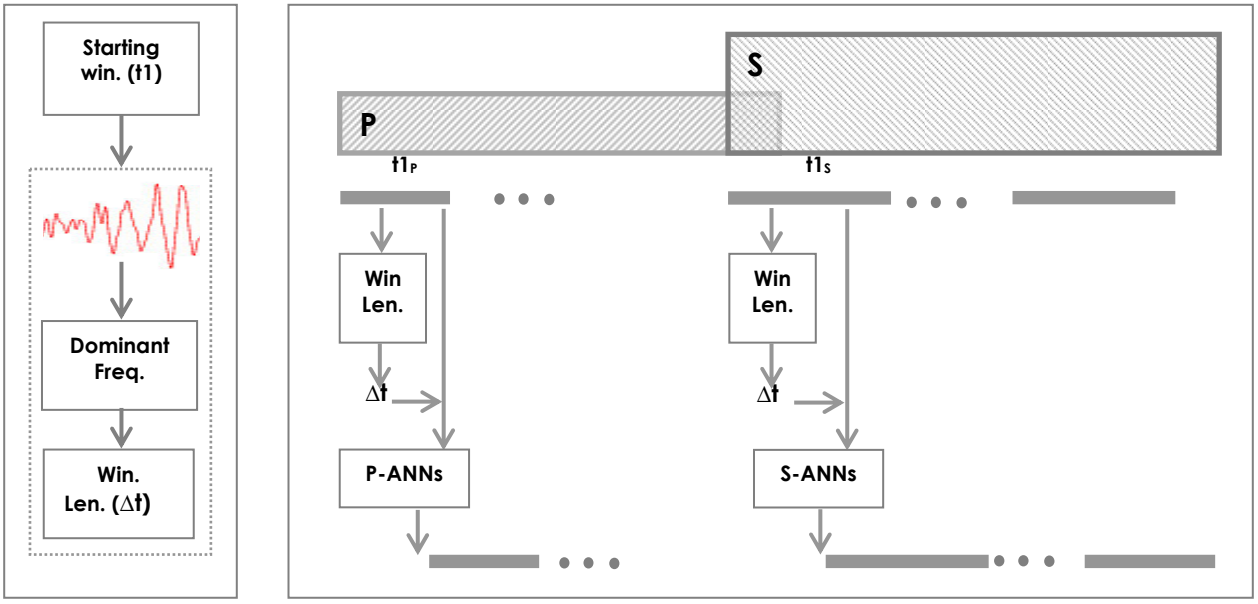
Real-time Frequency Adaptive Model to Predict Earthquake Load

Amin Zahédi Khaméneh

Objectives

Real-time generation of the earthquake signal is needed in building control systems, to trigger and control the actuators to reduce the building deformations. Although the conventional active control systems in some cases are able to reduce the response of the structure but because of the absence of a real-time data they are not capable to make a realistic and on-time reaction against earthquake load.

The objective of this work is development of an adaptive real-time prediction method to model the main characteristics of the earthquakes signal. According to non-stationarity of the seismic wave process, the strong ground motion prediction must be performed for each wave type separately (P, S, C/G waves). Hence an important part of the method is to detect and separate P and S waves. The prediction will be performed via adaptive windows length to make the ability of catching the dominant frequency and generation the most proper results in the frequency domain.



Determination of the windowing length and the procedure of the real-time prediction model

Approach

The method is based on the non-homogeneity of the seismic process which contains several wave types with their individual frequency domains and time-dependent amplitude form. Artificial neural networks (ANNs) will be used to simulate the features of the seismic process. Because of the non-stationarity of the seismic signal it is not possible to use constant predefined windows length. Therefore a three steps approach will be used to determine the widowing length. First, a starting window will be adjusted. Second, the dominant frequency will be computed by mean of the runtime efficient method of zero crossing analysis. Third, the length of analysing windows will be determined based on the dominant frequency. This three steps approach will be repeated for each analysing window.

It is widely known that the frequency and amplitude are following different patterns for P and S waves as well as for different epicentral distances. Therefore we have developed a nine classification prediction model (three wave phases times three epicentral classes). The investigation data will be selected according to the soil condition and moment magnitude (moment magnitude greater than 6 and soil type C and D according NEHRP). To model the amplitude form of each wave type, a polynomial regression model will be developed, which scales the predicted signal to the predefined amplitude pattern.

Research Contracts

Title: **Mefisto – A model, information and knowledge management platform in AEC**
(Mefisto – Eine Modell-, Informations- und Wissensplattform im Bauwesen)

www.mefisto-bau.de

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

Financial Support: BMBF (German ministry of education and research)

Budget: 9.9 million Euro (total), 1.5 million Euro (CIB), Duration: 3 years

Approach: Mefisto is the BMBF lead project in construction IT that aims at developing an overall framework and a visual platform for the management of the multi-model world of AEC projects based on a process-centric approach to construction work. It defines a structured set of information models subdivided into several layers with regard to the represented information (building product, building site including equipment and materials, building organisation including workers, managers and other relevant roles, work functions, work schedules, costs, risks and uncertainties). Interoperability of the modelling data will be achieved via a common platform ontology, the developed Mefisto Container concept, capturing various process-related views, and a set of interoperability services achieving the needed filtering and mapping data transformations both horizontally (between different models on one and the same level of abstraction) and vertically (to/from the different levels of abstraction within one model schema, thereby enabling appropriate information aggregation and expansion). These interoperability services will be embedded in an overarching process management approach providing for dynamic definition and run-time application of process modules on the basis of reusable reference process patterns incorporating compositional, contextual and strategic knowledge. Using these newly developed services as well as available sophisticated systems for construction management, controlling, geometry modelling and simulation, which will be extended in the frames of the project, Mefisto will achieve:

- Flexible and efficient construction site configuration
- Process representation and information views on different levels of granularity
- Semi-automatic creation of simulation model so that simulation tasks can become affordable not only to large-scale projects
- Semi-automatic conflict detection by various logistics and construction tasks
- Integrated controlling and management, bridging the gap between contractor and client but at the same time observing contractual and security constraints.

From IT point of view the overall system will be an open, distributed modelling and service framework enabling plugging-in of third-party tools both locally, as extension of available systems, and centrally, as commonly accessible web services. Special attention will be paid to the development of various innovative visualisation techniques to enable efficient navigation and examination of different aspects of the multi-model project world, such as 4D and 5D viewing/navigation, topological views, cockpit functionality for examination of critical values and visualizations of abstract networks resulting from costs, time, risks, and other interdependent models etc.

Partners: TU Dresden, Institut für Bauinformatik - Coordinator, AEC3 Deutschland GmbH (München), Ed. Züblin AG (Stuttgart), gibGREINER GmbH (München), Max Bögl Bauservice GmbH (Neumarkt), RIB Software AG (Stuttgart), SimPlan AG (Maintal), Solidpro GmbH (Langenau), TU Dresden: Institut für Baubetriebswesen, Institut für Software- und Multimediatechnik, Bauhaus-Universität Weimar: Professur Baubetrieb und Bauverfahren, Ruhr-Universität Bochum: Inst. für Informatik im Bauwesen

Title:	**BauVOGrid – a Grid-based platform for virtual organisations in construction** *(BauVOGrid – Grid-basierte Plattform für die Virtuelle Organisation im Bauwesen)* www.bauvogrid.de
Project Leader:	Dr.-Ing. Peter Katranuschkov
Financial Support:	BMBF (German ministry of education and research)
Budget:	2.4 million Euro (total), 0.4 million Euro (CIB), Duration: 3 years
Approach:	VOs typically include dozens of subcontractors and are characterised by highly complex partner inter-relationships. Distribution of work and responsibilities are non transparent and error-prone, often leading to considerable time and cost loss. BauVOGrid sets out to help improve VO operability and efficiency by developing a hybrid Grid- and Web-Service based platform that enables (1) the formal computer-interpretable representation of authorisation, access control and responsibility structures, (2) the configuration, instantiation and management of both global VO-processes and local partner-internal activities, as well as ad-hoc changes in the project workflow, and (3) flexible access to various kinds of information services both in the office and mobile, at the construction site. The envisaged infrastructure is achieved by integration of four cutting-edge information technologies, i.e. Grid, Semantic Web, Process modelling and management based on object-oriented eEPCs, and mobile gird-based information and workflow management. The BauVOGrid project contributes to the improvement of VO structuring and operability through an innovative VO environment that builds upon prior developments within the German D-Grid initiative and earlier EU projects of the partners such as InteliGrid and K-Wf Grid. Main application targets chosen to verify the developed approach and provide short-term practice results are defect management and selected aspects of facilities management within a real industry pilot (the new Dresden soccer arena "Rudolf-Harbig-Stadion") as well as aspects of IFC-based design collaboration.
Partners:	TU Dresden, Institut für Bauinformatik – Coordinator, Fraunhofer-Institut für Rechnerarchitektur und Softwaretechnik FIRST (Berlin), Institut für Wirtschafts-informatik im DFKI (Saarbrücken), IDS Scheer AG (Saarbrücken), SEIB ITC GmbH (Würzburg), Bilfinger Berger AG (Mannheim), BAM Deutschland AG, Niederlassung Dresden, RIB Information Technologies AG (Stuttgart), Bundes-verband Bausoftware e.V.

Title:	**Trans-IND – New Industrialised Construction Process for transport infra-structures based on polymer composite components)** www.trans-ind.eu
Project Leader:	Prof. Dr.-Ing. R. J. Scherer
Financial Support:	EU - EC FP7, GA NMP2-LA-2009-229142
Budget:	6.1 million Euro (total), 0.2 million Euro (CIB), Duration: 4 years
Approach:	Polymer based manufactured components for construction applications have been designed, developed and demonstrated in several European projects such as HP FUTURE-Bridge, SAFEFLOOR and MEGAWIND. The findings of these projects have been very promising with regard to customer requirements, quality, technical and economical feasibility and the favourable impact of using this kind of composite-based components in terms of sustainability, safety and quality of life. However, there is still a need to industrialise the whole construction process of the Fibre Reinforced Polymers (FRP) components in order to achieve real practice results. Furthermore, integration of the entire supply and value chain is needed, as well as the development of a high technology for design and manufacturing of FRP components, to transform on-site construction to off-site manufacturing. To answer such challenges Trans-IND sets out to develop a cost-effective *integrated construction process* based on innovative product and process management methods that will enable the maximum capability of industrialisation of components for transport infrastructures such as road

	and pedestrian bridges, underpasses, acoustic and safety barriers using polymer based materials (carbon fibre, glass fibre). The project outcomes will be demonstrated, as a pilot case, for components of a bridge (beams, preslabs) due to the high complexity in the bridge components manufacturing and assembly compared to other applications.
Partners:	Mostostal Warszawa S.A. (Poland) – Coordinator, Acciona Infraestructuras S.A. (Spain), Advanced Composites Group Ltd. (UK), ASM Centrum Badan i Analiz Rynku Sp. z o.o. (Poland), D'Appolonia S.p.A. (Italy), Fundacion Fatronik (Spain), Fraunhofer-Institut für Produktionstechnik und Automatisierung IPA (Germany), Huntsman Advanced Materials GmbH (Switzerland), Consiglio Nazionale delle Ricerche (Italy); Institut für Verbundwerkstoffe GmbH (Germany), Labein Tecnalia (Spain), MIKROSAM (FYR Macedonia); Semantic Systems S.L. (Spain), TNO (Netherlands), TU Dresden (Germany), Universita Politecnica delle Marche (Italy), BV machinefabriek van Wees Tilburg (Netherlands), Gradbeni Institut ZRMK d.o.o. (Slovenia), Solintel M&P S.L. (Spain), Atos Origin S.A.E. (Spain)
Title:	**REEB – The European strategic Research Roadmap to ICT enabled Energy-Efficient in Buildings and construction**
	www.ict-reeb.eu
Project Leader:	Prof. Dr.-Ing. R. J. Scherer
Financial Support:	EU – EC FP7, Theme 3 "Information & Communication Technologies – ICT for Environmental Management & Energy Efficiency"
Budget:	1.2 million Euro (total), 0.13 million Euro (CIB), Duration: 2.3 years
Approach:	The aim of the REEB project is to facilitate co-creation of a Strategic Research Agenda (SRA) and a supporting Implementation Activity Plan (IAP) for sustainable and energy-efficient smart building constructions by and through the establishment of dialogue between interactive and complementary communities of practice from energy, environment, and building construction domains. REEB develops a community operating method that will allow these communities to act as breeding and nurturing grounds for innovation in bringing together the relevant organisations and stakeholders for the purpose of starting up "innovation cycles in ICT-based environment management and energy efficiency" in smart building constructions. The main outcomes will be (1) a SRA and detailed IAP for R&D and innovation in ICT supporting energy-efficient smart facilities, and (2) a comprehensive coordination of information exchange and dissemination between energy-related ICT projects in various EU, national, and global programs/initiatives, in terms of on-going research, developed solutions, standardisation efforts, etc. This includes organising events and communication channels for identifying, defining, promoting and stimulating the innovative use of ICT in the Sustainability and Energy Efficiency area to reach wide audiences and bring together all stakeholders from the enlarged EU and relevant global communities. The REEB consortium involves 8 partners with complementary expertise drawn from 6 European countries. They are supported in their effort to build up the REEB community and develop the vision, roadmap and implementation plan by a Special Interest Group whose members participate in community discussions and decisions, and provide active feedback to studies and analyses.
Partners:	Centre Scientifique et Technique du Bâtiment (France) - Coordinator, Technical Research Centre of Finland (Finland), Commissariat a l'Energie Atomique (France), Fundación LABEIN (Spain), Acciona Infraestructuras S.A. (Spain), Ove Arup & Partners international Limited (UK), University College Cork (Ireland)

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

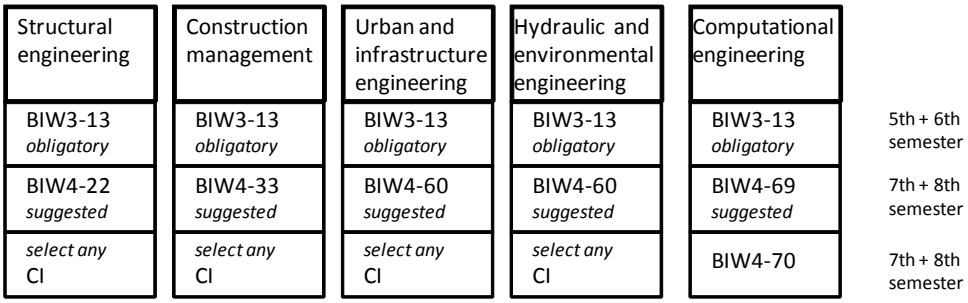
Title:	**Appraisal of Methods and Criteria for Sensitivity Analysis at Non-linear Structural Behaviour**
Project Leader:	Dr.-Ing. Uwe Reuter
Financial Support:	DYNAmore GmbH
Duration:	Since 11/2007
Approach:	Structures are described by structural parameters, e.g. for material behaviour. Structural behaviour under live load is simulated by computational models. Structural responses are thus assigned to structural parameters. However, structural parameters are subject to random variations, which can be described by probabilistic models. The property randomness of the structural parameters yields random structural responses. Investigation of the influence of such fluctuating structural parameters to structural responses is called *sensitivity analysis*. A lot of established methods on the basis of linear correlation models and criteria exist for sensitivity analysis of (approximately) linear structural behaviour but these methods are improper if there is a non-linear interrelationship between structural parameters and structural responses. Actual developments for appraisal of sensitivity of non-linear interrelationships are auspicious. Within the framework of this project advanced methods and criteria for sensitivity analysis at non-linear structural behaviour are appraised and implemented with the aid of proper software engineering techniques.

Lecture Activities

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

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

Diploma/Master course if construction informatics competence is chosen



Module BIW1-07: Construction Informatics Fundamentals

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

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

Module BIW2-09: Information Management and Numerical Mathematics

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

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

Module BIW2-15: System- and Information Modelling

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

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

Module BIW3-13: Construction Informatics – Advanced Fundamentals

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

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

Module BIW4-22: Cooperative Design Work and Numerical Methods

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

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

Module BIW4-33: Software Systems

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

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

Module BIW4-69: Simulation and Monitoring of Engineering Systems

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

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

Module BIW4-70: Model-Based Working

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

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

Module: Information Systems (read in English)

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

Subjects: This module is comprised of three parallel courses: (1) Management Information Systems, (2) Information Mining, and (3) GIS for Infrastructure Systems.
The first course introduces the methods for object-oriented modelling of complex engineering systems. Further course material focuses on communication methods and the formal representation of communication goals which allow the efficient application of automatic evaluation and decision support methods and algorithms. A third part of the course is specifically dedicated to the use of control methods and the development of a methodology for performance measurement.
The second course introduces methods for data analysis and data mining, such as correlation and regression, classification, decision trees and clustering, whose practical application aims at the early detection of damages and faulty system behaviour. In conjunction with that the scope of application and how the methods are complemented are discussed. Part of the course is specifically dedicated to data pre-processing since the efficiency of the methods strongly depends on the modelled data.
The third course provides an introduction into graph theory, by which the partitioning and the formal area-related variables dependencies can be described. The mapping from object-oriented data models to area-related representations and the generation of area boundaries by means of data mining methods are discussed. Different ways of graphical representation for complex, multi-layered information in terms of area magnitude are introduced. The lectures and tutorials provide insight into preferred modelling and data analysis techniques for corresponding graphical representation methods.

Course: Informatics in civil engineering

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

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

Publications in 2009

[1] FASCHINGBAUER G. & SCHERER R. J. (2009). Integrated Product- and Process Model for Online Prediction and Monitoring of Geotechnical Structures, in: Proc. 16th EG-ICE International Workshop, Berlin, Germany, Technische Universität Berlin.

[2] CHENG T., TEIZER J. & FASCHINGBAUER G. (2009). Advanced Real-Time Monitoring Models for Temporary Structures in Construction, in: Proc. ASCE International Workshop on Computing in Civil Engineering, Austin, TX, June 25, 2009.

[3] SHARMAK W. & SCHERER R. J. (2009). Adaptable Project Schedule Plans Using Change Templates. In: Proc. 18th International Conference on the Application of Computer Science and Mathematics in Architecture and Civil Engineering (IKM); K. Gürlebeck & C. Könke (Eds.), Weimar, Germany.

[4] DOLLMANN T., FELLMANN M., THOMAS O., LOOS P., HOHEISEL A., KATRANUSCHKOV P. & SCHERER R. J. (2009). Process-Oriented Collaboration in Grid Environments: A Case Study in the Construction Industry, in: Proc. 15th Americas Conf. on Information Systems (AMCIS), San Francisco, CA, 6-9 Aug. 2009.

[5] KATRANUSCHKOV P., RYBENKO K. & SCHERER R. J. (2009). Ontology-Based Dynamic Process Support on the Example of Defect Management, in: Proc. 26th CIB W078 Conf. “Managing IT in Construction”, Dikbas A., Ergen E. & Giritli H. (eds.), Istanbul, Turkey, 1-3 Oct. 2009, CRC Press/Balkema, ISBN 978-0-415-56744-2.

Positions in Editorial Boards of Journals

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

Membership in Standardization Groups

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